

Young women's longitudinal identity negotiations in physics and mathematics throughout upper secondary education

Emilie Gertz^{✉,*}, Lene Møller Madsen[✉], and Henriette Tolstrup Holmegaard[✉]

*Department of Science Education, University of Copenhagen,
Jagtvej 155A, 2200 Copenhagen N, Denmark*



(Received 11 September 2025; accepted 3 March 2026; published 15 April 2026)

Upper-secondary education has been identified as a critical period for understanding young people's (non)continuation in physics, as well as their broader trajectories into science, technology, engineering, and mathematics (STEM). This paper illuminates the longitudinal identity negotiations within upper secondary school physics and mathematics by focusing on two students, Kristi and Svea, who embody a paradox: Despite entering upper secondary school with strong science and mathematics identities and pursuing advanced coursework in both disciplines, they consistently refrained from considering futures in STEM. Central to our analysis is the concept of disciplinary and celebrated identities, which we integrate with perspectives from narrative psychology. This study draws on three rounds of semistructured narrative interviews with each student ($n = 6$). The analysis was carried out by applying an in-depth reflexive thematic approach, focusing on how gendered identities and power dynamics shaped the young women's negotiations within these masculine fields. The analysis showed how the two young women were presented with challenges in (i) aligning their interests and identity work with the disciplines' norms and practices, and that facing such narrative disturbances was a gendered experience; (ii) bonding with the teachers enabled recognition, even though it involved applying narrow masculine strategies; and (iii) having to submit themselves to a "sink or swim" culture amplified their sense of inadequacy and unfitness for evolving strong disciplinary identities. Our findings show that these factors together discouraged the young women from maintaining sustainable narratives and negotiating positive choice considerations for a future in STEM. From a diversity perspective, our findings illustrate that inclusion is not only about access to participation but also about whose interests and ways of meaning-making are valued and legitimized within disciplinary practices. In doing so, this study advances research on diversity and inclusion in STEM by showing how disciplinary identities are shaped through sedimented practices of recognition over time. The implications call for rethinking participation to embrace and foster gender-inclusive teaching and learning environments, for example, through reforms in teacher training. Finally, we argue for moving away from deficit framings that describe young women as lacking confidence in physics and mathematics. Instead, feelings of not being "clever enough" should be understood as a product of the field itself, shaped by disciplinary practices in school physics and mathematics.

DOI: [10.1103/v6h9-r7by](https://doi.org/10.1103/v6h9-r7by)

I. INTRODUCTION

Several studies have shown that young people's interest in and aspirations for mathematics and science (especially physics) decline during compulsory schooling [1–6]. In particular, girls and minorities struggle to see these subjects as something for them, even when they receive high grades [7,8]. This lack of identification with mathematics and science during compulsory schooling has

significant implications for representation in the fields of science, technology, engineering, and mathematics (STEM) beyond school. Consequently, in many western countries, women and minorities are underrepresented in postcompulsory STEM subjects [9], especially within the "core" STEM subjects such as physics and mathematics [10] (p. 156) and at the degree level in the physical sciences, engineering, and mathematics [10–13].

This underrepresentation in STEM fields underscores the importance of understanding critical junctures in education. In this regard, the upper-secondary level has been highlighted as a critical period for understanding the non-continuation of women and minorities into STEM in particular [14–16]. It is during adolescence that young people often shape and solidify their aspirations for future education [17]. Hence, upper secondary education is a

*Contact author: eg@ind.ku.dk

Published by the American Physical Society under the terms of the Creative Commons Attribution 4.0 International license. Further distribution of this work must maintain attribution to the author(s) and the published article's title, journal citation, and DOI.

pivotal phase where students align “who I am” with “who I want to become” [18]. Given this pivotal role of upper secondary education in shaping continuation with STEM subjects, it becomes particularly important to investigate how women experience the discipline of physics and mathematics during this critical phase, especially those who, upon completing compulsory schooling, perceive these subjects as relevant, meaningful, and something for them.

Identity, as a theoretical lens, provides a valuable framework for exploring how students engage with, participate in, and make choices about STEM subjects [15,19,20]. For example, within upper secondary school science and mathematics, the concept of disciplinary identity has been employed to examine how classroom norms and practices interact with identities that are possible to form within the school disciplines [21–23].

Researchers have highlighted the importance of longitudinal studies for understanding students’ educational trajectories and career aspirations [24]. Drymiotou *et al.* [24] specifically emphasize the importance of examining these trajectories from secondary school to career pathways. This call is particularly relevant for identity studies, where such longitudinal approaches have been identified as a crucial “next step” [25–27].

Looking at existing longitudinal research on students’ identity, it becomes evident that the focus has largely been on either science/physics identities or mathematics identities. For example, Calabrese Barton *et al.* [7] conducted a three-year study on the science identity trajectories of middle school girls. Their findings demonstrate that when the identity work of girls from nondominant backgrounds is recognized and supported, these students are better able to imagine future selves in science. This underscores the critical role of recognition in shaping identity trajectories, providing a foundation for further exploration of how such factors influence identity over time.

In a different longitudinal study, Carlone *et al.* [28] explored identity changes in the contexts of fourth- to sixth-grade science classes. Their longitudinal approach offers insights into how classroom practices and perceptions of legitimacy shape students’ connection to science. They found that although the students initially held positive perceptions of science, their views shifted over time, concurrently with changes in teaching activities and as recognition of participation as legitimate varied over time.

The interplay between identity development and systemic barriers becomes even more evident in the work of Archer *et al.* [29], who studied the identity trajectory of Venessa, a Black working-class young woman. Initially passionate about science, Venessa’s identity was gradually eroded by social and educational inequalities, leaving her feeling discouraged and excluded by the time she was 18 years old. This case highlights how structural inequalities can hinder students’ access to STEM fields, particularly for those from marginalized backgrounds.

At the university level, Quan *et al.* [30] explored how identity develops within the physics community through a longitudinal case study of a physics undergraduate, Cassidy. The authors analyzed shifts in Cassidy’s participation across two contexts: undergraduate coursework and research experiences. Their study highlights how alignment between personal and normative identities influences inclusion and persistence in physics.

Longitudinal studies on science or physics identities are more prevalent than those focusing on mathematics identities. Addressing this gap, Archer and Mendick [19] provide a novel contribution by examining the mathematics identity development of three young men from the age of 10–21 years. Their findings illustrate how mathematics capital, encompassing economic and social resources, plays a pivotal role in sustaining and nurturing mathematics identities over time. This study not only expands the scope of identity research but also highlights the potential of longitudinal approaches to uncover the complex interactions between resources and identity in STEM fields.

These longitudinal studies reveal that identity over time is not a linear process. Instead, identity is a process where students work to create meaning, highlighting the importance of examining identity over time to better understand the dynamic nature of identity construction [23]. We therefore aim to fill the gap in the research literature on longitudinal studies by providing novel research on the evolution of students’ disciplinary identities during their upper secondary education. We do this by exploring the identity negotiations of two young women, Kristi and Svea, as they stand out in at least two regards. First, they leave compulsory schooling with strong mathematics and science identities. Second, unlike many other students, they choose to continue with and finish upper secondary school with level A in both physics and mathematics. Despite this engagement with physics and mathematics, both Kristi and Svea negotiate their choice considerations for a future in STEM with a negative outcome. This raises the question of why their strong disciplinary identities in physics and mathematics do not evolve and flourish during their upper-secondary education.

II. NARRATIVES, NEGOTIATIONS, AND BELONGING

In this paper, we seek to understand young women’s engagement with and transitions through upper secondary school physics and mathematics, and how their interests, participation, and future aspirations are formed over time. Drawing on disciplinary identity and narrative psychology, we conceptualize identity development as a narrative process shaped by practices of recognition and a sense of mattering and belonging within disciplinary contexts. These practices are embedded in power relations that render

some storylines more accessible, legitimate, and sustainable than others.

A. Disciplinary identity

Disciplinary identity has been conceptualized as an understanding of how individuals make sense of themselves and are made sense of by others with respect to a discipline [21]. According to Kane [21] disciplinary identities are formed in alignment with academic norms and practices while participating in and constructing knowledge within the scientific community of the classroom. This means that, for example, in school science, students' identities are shaped as they engage in constructing scientific knowledge and participating in scientific processes within the classroom's scientific community [21].

Entering the realm of mathematics and science classrooms, our conceptualization of the disciplinary identities draws from what has become a seminal model of science identity developed by Carlone and Johnson [31] and the idea of the celebrated student [28]. Through women's narratives about their experiences with science, Carlone and Johnson examine the multiple ways in which identities are shaped within a complex network of recognition practices situated in specific scientific contexts. They explore how these practices enable and constrain the development of science identities. Here, a person's science identity is narrated through interrelated and overlapping dimensions of science performance, competence, and recognition [31]. It is important to emphasize that science identity is not just about recognizing oneself, but being recognized by significant others is just as important. (Re)constructing identities in science is a dynamic and multifaceted process that involves both of these processes. These processes are deeply influenced by cultural norms and contextual expectations regarding who is seen as a "science person" and who is deemed capable of becoming one, particularly in relation to what is celebrated, valued, and acknowledged within a given context [31]. Hence, the criteria for being recognized can change across contexts and even vary among students within the same context. The model has been extended with the addition of interest as a fourth dimension to understand upper secondary school students' physics identities [15] and for studying mathematics identities in the world of mathematics [32,33].

To understand students' experiences with and attitudes toward mathematics and science over time, scholars have used the term identity work to illustrate the ever-changing and dynamic process of making oneself recognizable and recognizing oneself within the learning context [7,19]. Identity work is thereby not a linear process; it is an ongoing process of negotiations shaped by culture and expectations within the subjects. This means that identity work does not happen in isolation or within a neutral space. Rather, it is deeply embedded within complex power dynamics that shape who is valued and celebrated in the

disciplines [34]. Below, we describe how we conceptualize this. In this study, we draw on disciplinary identity primarily to understand how recognition and participation shape students' sense of belonging over time, rather than to categorize individuals as either having or lacking a science identity.

B. Narratives and identity work

To further conceptualize identity work, we turn to narrative psychology, which has proven valuable in understanding longitudinal data, particularly in contexts where young people encounter new experiences, such as the transition to and throughout higher education [35], or upper secondary school, as is the focus of this study. We present three key elements that we draw upon: (i) meaning-making and the sense of mattering, (ii) temporality, and (iii) cultural storylines.

Narratives are *meaning-making processes* through which individuals make sense of their experiences while connecting these experiences to their identities [36]. Thus, identity work in narrative psychology refers to the double-sided process of constantly making sense of the world while simultaneously striving to relate oneself to it [37]. The years spent in upper secondary school are intense and filled with new experiences, leading to potential changes in not only the narratives the young women in this study construct but also their interpretations of the world around them. What may seem central to their narratives at one time can fade into the background later as they encounter new experiences [38]. This study examines the identity-processes among young women in the subjects of physics and mathematics. A crucial aspect of developing stable and positive disciplinary identities over time is fostering a sense of mattering and connectedness. Such feelings are fundamental in cultivating a sense of belonging [39], which, in turn, supports sustained participation and allows students to envision future orientation within the discipline.

Narratives are continuously negotiated as the individual is presented with new resources through which they can understand themselves [40] (p. 1). Interviewing students at various times provides access to the resources the young women draw on when making meaning of themselves in relation to the disciplines. Over time, some might come to see themselves as more clearly belonging to the disciplinary context, while others do not, or some might feel affiliated with certain disciplinary practices and not with others—this is our focus in this paper.

In narrative psychology, identities are seen as dynamic and continuously evolving, shaped by our experiences over time. However, this differs from perceptions in everyday life, where identities are perceived as accumulating over time, meaning that we expect relatively stable selves from each other. To present a coherent representation of the self, we are constantly engaged in *temporal narrative alignment* of our past, present, and future, integrating new experiences

within past preferences, and while considering future possibilities [41]. Thus, temporality is an inevitable part of identity work, and our focus in this study is on how thoughts about the future are constructed over time.

While narratives provide insights into individual identity processes, these processes are inherently embedded within social and cultural contexts. To fully understand how students engage in identity work, it is essential to consider the context and practices that shape their beliefs about what is possible, desirable, or achievable [42,43]. For young women in mathematics and science, this means navigating and relating to existing *social and cultural storylines* about what, for example, physics is and who qualifies as an “ideal” physics student—a theme we revisit in the section on the “axis of power.” Although individuals cannot entirely “escape the plot,” they do play an active role in authoring their narratives. These stories, which enrich and shape self-understanding, are interwoven with the collective meanings and shared interpretations of their cultural context. As Bruner [36] (p. 13) aptly notes: “we live publicly by public meanings and by shared procedures of interpretation and negotiation.” This interplay between personal agency and cultural constraints underscores the dynamic nature of identity work, where individuals craft their narratives within the boundaries of the cultural frameworks available to them.

C. Negotiations and disturbances

Turning points have been introduced as a concept in psychological and sociological research to examine life transition phases, such as the complex journey into adulthood [44,45] or when addressing life challenges that may lead individuals toward life changes like criminal behavior [46]. While such studies tend to focus on how structural events set the scene for forming a narrative about yourself (such as the experience of getting a life-threatening disease [47]), we suggest that turning points are more subtle processes in the identity work, and therefore call them disturbances to emphasize that identity change is not driven by isolated events, but by how such moments are narratively interpreted and negotiated over time. We aim to explore the nuanced experiences of young women as they navigate through their narratives of continuity and discontinuity during the interviews. We argue that disturbance manifests in their narratives as those pivotal moments that prompt a shift in their meaning-making processes regarding how they relate to the disciplines they engage with. These moments can be characterized by feelings of doubt or transformation that reshape their understanding of themselves and their place in the world around them.

By employing disturbances as an analytical lens, we seek to approach the negotiations that occur in the interviews over time. These negotiations involve the ongoing development of individual identity and the complexities of social and cultural influences surrounding those identities. Understanding disturbances allows us to comprehensively

examine how young women meet and are met by the challenges and opportunities they encounter and how their evolving sense of selves is entangled with the cultural and social setting of the disciplines they meet.

Across the analytical framework, power is understood as embedded in disciplinary practices of recognition and participation. These practices shape which ways of engaging, interests, and identities are rendered legitimate; who is valued and celebrated in the disciplines [34]; and thus who can plausibly develop a sense of belonging within physics and mathematics. Such power dynamics are inextricably linked to entrenched cultural norms and intersect with social categories, including gender [48], as dominant disciplinary norms in physics and mathematics are historically and culturally aligned with masculine-coded practices and expectations. These intersecting power dynamics profoundly shape not only how young women perceive themselves but also how they are perceived and recognized as learners in mathematics and physics. Thus, the process of self-recognition and gaining recognition by others is shaped by societal norms, institutional practices, and implicit expectations [19,48] that produce participation and belonging within disciplinary classrooms.

In this paper, our specific focus is on the ways in which gender both shapes and is shaped by the narratives young women construct as they navigate these fields. We conceptualize gender as a social construct [49] that emerges through the norms, practices, and cultural resources available within the disciplinary classrooms. These cultural resources provide young women with the resources to narrate their identities; however, they are simultaneously constrained by the dominant narratives that define who belongs and who does not. By examining the interplay between these cultural resources and the narratives young women construct, we aim to illuminate how gendered identities are negotiated, affirmed, or contested within these disciplinary spaces.

In this paper, we primarily draw on disciplinary identity and narrative identity work, using disturbances as the key analytical device to trace how gendered power relations shape recognition, belonging, and future orientations over time. We do so by following the process of how two female students—Kristi and Svea—make sense of themselves and are made sense of by others, and how they continuously (re)negotiate their disciplinary identities within the context of upper secondary education. To address this, we propose the following research question: How do Kristi and Svea negotiate their disciplinary identities, related to upper secondary school physics and mathematics, throughout their education, and how do these negotiations intersect with gender and ideas of future?

III. METHODS

In Denmark, there are four different upper secondary educational programs; this study is situated within the

general upper secondary education program (STX) [50]. The students are offered different study programs with both compulsory and elective subjects (level A is the highest, B is the middle, and C is the lowest). The transition from compulsory school to upper secondary represents a shift in how subjects are taught, as physics (and chemistry) are taught separately, unlike the integrated approach used in compulsory school. Hence, when referring to science in compulsory school, it includes physics.

Students are usually around 16 or 17 years old when entering the three-year upper secondary education. Throughout this period, evaluation and grades are given based on participation in class and oral and written exams. Admission is free, and students older than 18 years receive state grants (nonrefundable) to cover basic living expenses.

A. The study

The data used in this paper are drawn from a longitudinal qualitative Ph.D. project with 32 self-identifying young women in a Danish upper secondary school. The project focuses on how their science and mathematics identities evolve throughout their education and how these disciplinary identities are interwoven with their choice considerations for a future in STEM. The 32 young women were attending three different schools and were enrolled in three different study programs. The schools varied in size, the proportion of female students, overall grade point average (GPA), and students' socio-economic background. All 32 young women had mathematics level A combined with varying science subjects (biology, biotechnology, chemistry, physical geography, and physics) and varying attainment levels. Some of the science subjects were actively chosen, while others were mandatory. The 32 young women were selected based on a questionnaire to obtain maximum variation regarding the prior and current relationship with mathematics and science, social background, and ethnicity [51]. The data consist of qualitative interviews with each young woman

during their three years of study, for a total of 97 (one dropped out after the first year).

This paper focuses on two young women, Kristi and Svea, who both chose to continue with level A physics and mathematics. They were located at two different schools. Kristi has a middle-class background, and Svea has a working-class background.

B. Narrative interviews

Interviews were carried out by the first author and took place in each of the three years. They were conducted individually at the schools during school time and carried out as semistructured [52] with a narrative interview approach [53]. Each interview round had the same main themes but differed in the specific themes. The distinction between main and specific themes indicated the difference between the focus and the range of the questions, but both types of themes were covered during the interviews. The main themes provided for a more open discussion, letting the young women take the conversation in different directions. The specific themes had an in-depth and narrower focus. Subquestions were prepared under both types of themes. Table I provides an overview of the different interview rounds and their themes.

The interviews lasted for 40–60 min during the first round, around 60 min during the second round, and 50–80 min during the third round. Prior to the first round of interviews, the young women signed a consent form following the ethical guidelines at the University of Copenhagen. Before each interview, the interviewer (re)informed the participants about anonymity, confidentiality, and data protection.

A fourth point of data collection was conducted via text messages approximately six months after their graduation. The young women were asked to elaborate on their completion of upper secondary school, their experiences with finishing physics and mathematics, their current activities, and their thoughts about the future.

TABLE I. Overview of the interview rounds and themes.

Interview round		1	2	3
Main themes		Upper secondary school experience in general Experiences with mathematics Experiences with science Future perspectives		
Specific themes	Prior experience with mathematics and science	Transition from the first to the second year		Transition from the second to the third year
	Expectations for mathematics and science	Norms and practices in science and mathematics		Norms and practices in science and mathematics
	Transition into upper secondary school	Competencies and performances on written assignments		Gender
	Considerations when choosing the study program	Gender		Drawing an imagined future

C. Analysis

The analysis was carried out in two steps—initial and main—through a reflexive thematic approach [54,55] while coding in NVivo. The initial analysis formed the foundation for focusing on the two female students, Kristi and Svea.

First, an overview was created of the 32 young women's interests, aspirations, and experiences with science and mathematics across the three rounds of interviews. Based on the overview, we focused on the young women who chose to pursue level A science subjects (physics or biotechnology) and level A mathematics, but, despite their choice, expressed no interest or negative considerations about pursuing a future in STEM throughout the interview rounds. This group was particularly interesting, as their narratives revealed complex negotiations of disciplinary identities, meaning-making processes, and subtle tensions between their aspirations for the future. Consequently, we identified a group of young women who continued into level A science subjects (physics or biotechnology) and mathematics without aspiring to translate these choices into higher education. Four women within this group were identified. Finally, we selected the young women who had positive relationships with both science and mathematics and narrated strong science and mathematics identities upon completing compulsory schooling. This selection enabled us to examine how these positive relationships were either nurtured or neglected as the students progressed through their level A courses, offering insights into why they struggled to envision themselves pursuing a future in STEM. This process ultimately led to a focus on two students, Kristi and Svea, who both studied level A physics and mathematics.

The main analysis involved carefully reading through the two young women's interview transcripts—three

transcripts for each of the two women. This iterative process of reading and rereading facilitated familiarization with the data, allowing for an in-depth engagement with their narratives. Next, the data were analyzed by asking: How do Kristi and Svea conform, contest and negotiate their disciplinary identities related to physics and mathematics throughout their upper secondary education? Initial themes and topics were identified through a close analysis of the narratives, with a focus on how the two women constructed, negotiated, and renegotiated their disciplinary identities over time. These were discussed and revised by the three authors. This reflexive approach enabled ongoing dialogue between the data, the theoretical framework, and interpretative analysis. Relevant quotes were selected to illustrate central aspects of Kristi's and Svea's identity work and meaning-making within their narratives, shedding light on how they navigated tensions of continuity, discontinuity, and disturbances. Initial themes of identity negotiations and meaning-making processes were created for each year in relation to physics, mathematics, gendered experiences, and ideas about the future. In the following section, these findings are presented.

IV. RESULTS

Here we present the findings. We begin with two graphic overviews (Figs. 1 and 2) that illustrate the two students' negotiation patterns over their three years of upper secondary school. These figures are intended as a guide for reading the subsequent analysis. After this visual introduction, we examine Kristi's and Svea's negotiations and identity work over time—starting with their first year (Sec. IV A), then moving to their second year (Sec. IV B), and finally their final year (Sec. IV C). This section concludes with a short summary (Sec. IV D) in which

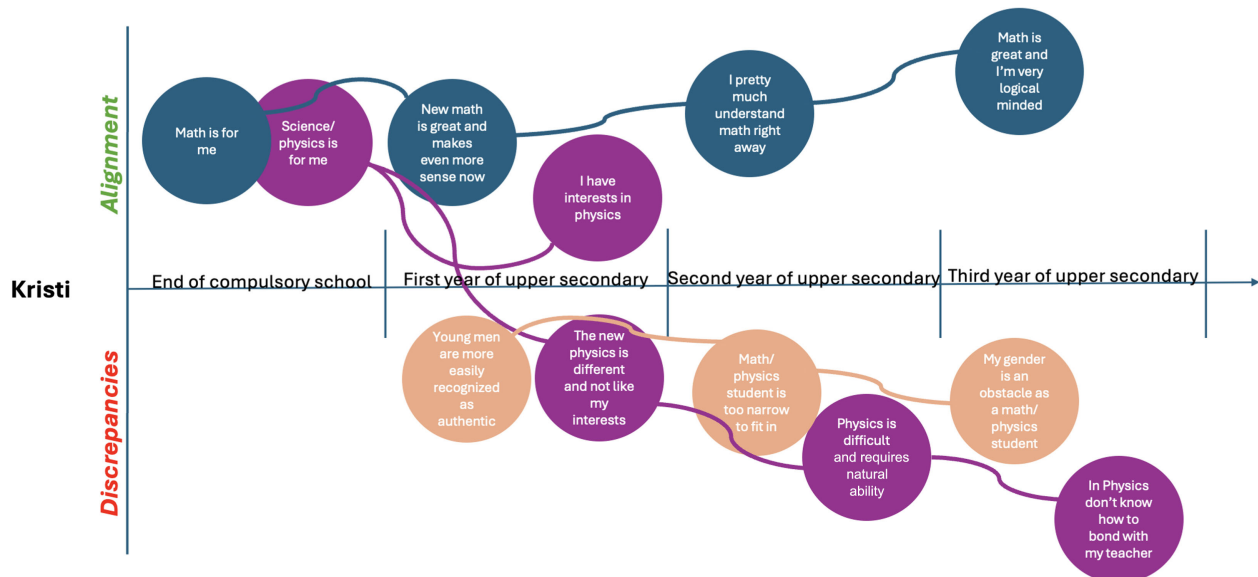


FIG. 1. Kristi's negotiation patterns.

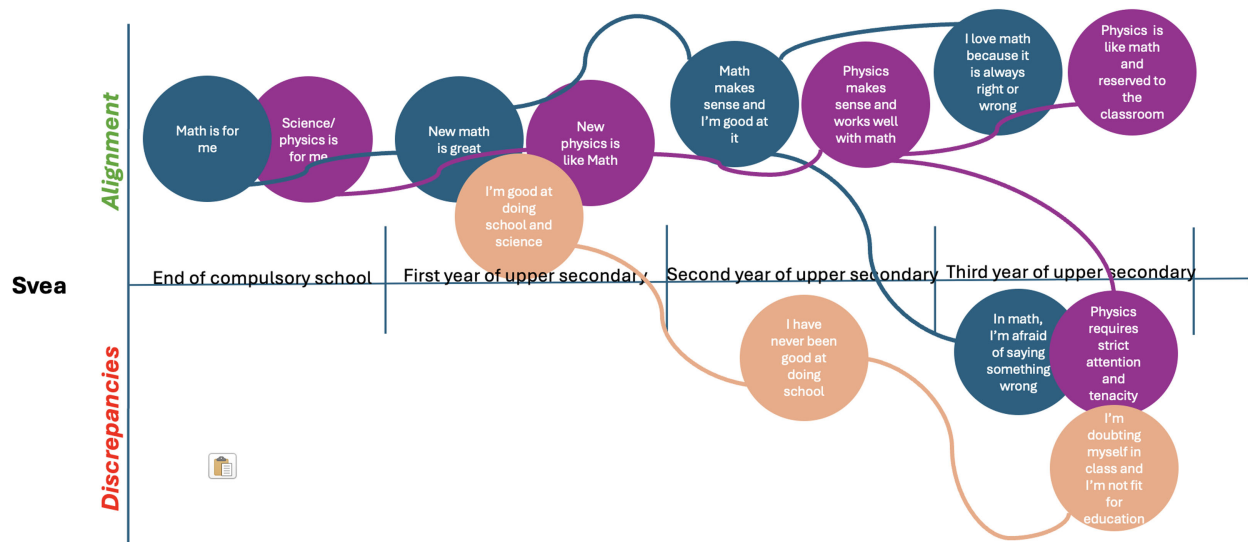


FIG. 2. Svea's negotiation patterns.

we use the metaphor of “swimming and sinking” to illustrate how the two students’ disciplinary identities develop as they negotiate their considerations for a future in STEM.

Figure 1 illustrates Kristi’s negotiation patterns, and Fig. 2 illustrates Svea’s. The analytical categories—mathematics (blue), physics (purple), and gender (orange)—are represented as separate circles. It is important to note, however, that these categories do not function independently in practice; rather, they are intertwined in the students’ lived experiences. Each circle includes examples of narratives, representing moments of either alignment or discrepancy within these categories. The horizontal axis in both figures represents the temporal progression, beginning at the end of lower secondary school and continuing throughout the third year of upper secondary school. Crossing the temporal axis is a vertical axis that displays narrative alignment (green) above the temporal axis and narrative discrepancies (red) below it. Accordingly, colored circles placed above the horizontal axis indicate moments of narrative alignment, while colored circles positioned below the horizontal axis represent narrative discrepancies. Narrative disturbances and negotiations emerge through the interaction between alignments and discrepancies.

A. First year: Transition into upper secondary school

1. Kristi

In the first year, Kristi began to negotiate her experiences as a physics learner. Physics as an upper secondary school subject seemed different than her prior experiences and her

expectations of the subject. She explained why she enjoyed physics during compulsory schooling was founded in:

I really liked [physics], and I also liked the fact that our whole, what can you say, the world, the earth, is kind of based on physics [...] So, you can’t find something that is not somehow connected back to some form of physics.

Her experiences with learning physics during compulsory education implied relatable, meaningful, and purposeful learning experiences. She described how she came into upper secondary with a strong interest in and fascination with space and astronomy. She had always been “someone who looks at the stars” through a scope and followed the news when a new space telescope was sent into space. She could not “help thinking about how we are such a small part of something so ... incredibly vast, and I really want to somehow be involved in looking at what exists beyond Earth.” When choosing to continue with physics in upper secondary, she expressed how her expectations were to learn that “physics is really just what we live in, that everything is physics.” Nevertheless, what she experienced in upper-secondary physics was the following: “I don’t know how much we’ve learned about that yet, [...] it’s more like formulas and stuff like that.” Nevertheless, Kristi explained how she prioritized her science-homework (in physics and chemistry) as these subjects were intentionally chosen in contrast to the mandatory subject Danish, underlining her desire to persist even though the transition from compulsory schooling seemed challenging.

Kristi experienced a disturbance in her meaning-making process of physics. She negotiated this change and her need

for continuity by conforming to the new form of physics in several ways. The first relates to understanding the teacher intuitively (grasping without effort), with the consequence of being reduced to a passive learner:

Well, at least many of my science teachers, they talk to, or try to teach us things, as if we already know it. [...] I really just have to listen to what they say, but it's sometimes hard to understand because they talk with words that we haven't learned.

Therefore, needing to learn words and content before reaching an understanding created a feeling of being inadequate. More specifically, Kristi explained how in physics the responsibility of understanding the content was placed on the individual student: "our teacher, he talks a lot, and we sit for a while and try to make head and tails of it all, but it's a bit difficult because he just talks." Instead, when she asked for clarification from the teacher, her voice was silenced, and she was reduced to being a recipient of knowledge disseminated by the teacher: "So if you ask about something, he says he'll get back to it later, but [...] it is not certain that you will be there when he returns to it." In this way, conforming implied understanding the teacher right away as anything else would create uncertainty.

The second way that Kristi negotiated the change in physics concerned the binary structure of physics with correct versus wrong answers. This structure was highlighted as a clear path to gain recognition as opposed to the structure of learning Danish and English, in which she felt recognition was more ambiguous: "something you feel." However, this instant path to recognition—where correct answers were tied to gaining recognition—also meant that answering incorrectly was a way to be recognized as being wrong:

I find it a little nerve-racking to say anything because ... I don't know. I don't have ... I don't have anything to impress, anyone to impress, apart from the teacher. But if they say it's wrong, then that's such a bummer, so I'd rather just not say anything.

So, answering incorrectly in physics created a feeling of being wrong in physics, and as a result, Kristi negotiated her sense of belonging in physics.

Finally, Kristi negotiated the discrepancy between her desire to learn about physics in everything and what she experienced in physics class by hoping for a change when advancing during her education: "Maybe [first year] is a little more like you have to learn everything, and then 2nd and 3rd can be a little freer, I hope." Kristi's hope for a "freer" learning experience with physics underlined a desire to recapture with learning "physics in everything" and a feeling of having to conform to a specific way of doing

physics, where she was forced to leave aspects of herself (e.g., interests) outside, as these were not recognized in the learning context. As such, she was trying to make temporal alignment in her meaning-making of physics as she experienced it before and experienced it now. So, even when feeling wrong, inadequate and with no room for own interests in physics, Kristi tried to conform and adjust herself to fit in, albeit with a hint of doubt: "I guess I also have to learn this [new way of doing physics], but I don't know [...] if it is something you can get used to." In this way, Kristi negotiated her narrative of having a strong physics identity from compulsory school, striving to maintain it despite the challenges, as it was incompatible with the new context of upper secondary school physics.

In relation to mathematics, Kristi explained how in compulsory school she belonged to the best group of pupils. Here, being best was determined by being fast and doing extra assignments. She described how mathematics had changed when entering upper secondary, now they would have to "prove the formulas and why they work and like how it all fits together. Which I somehow like better." In this new way of doing mathematics, she was able to find meaning in learning the subject: "I have always wanted an explanation of where it all comes from. Where, when I have made a proof of it, I feel completely relaxed and think, now I truly understand why it is the way it is." In contrast to her experiences in physics, Kristi was at ease with creating temporal alignment in mathematics between being fast (before) and understanding (now). Furthermore, she could recognize herself when learning the subject:

When I'm doing math, I can just ... it just flows [...] Because ... I don't know ... um ... it's like the whole ..., everything just ... it's like a puzzle that just comes together in my mind, where it all just makes sense.

So, doing mathematics, in her mind, gave her a feeling of fitting in. She described herself as: "I think very logically" and grasping the essence of learning mathematics was inevitable for her: "I don't think that I can leave a mathematics lesson without it makes sense. [...] It always ends with I get it." Thus, even though mathematics had changed when entering upper secondary school, this new way of doing mathematics seemed like an even better fit for her. Here, she was able to form a stronger sense of belonging in her disciplinary identity than before, as she could draw on being naturally fit for it and thereby be recognized by others. She described this naturalness as aligned with her father, who had a bachelor's degree in mathematics, and as opposed to the rest of her family, who could not do mathematics but instead were good at Danish:

Me and my dad, we're like, we can't read half a page before we find it annoying. We much prefer looking at things logically, like mathematics and

that sort of stuff. [The others] just can't see it the same way as us.

So, she recognized herself and was recognized by her father (a math-person) as being an inherent math-person, opposed to being a Danish-person.

Despite thriving in mathematics, Kristi found herself negotiating her gender as a math or physics student. She was in a class with half math or physics students and half language students and she described how other students often mistook her for being a language student: "I don't know if I'm the type they expected [to be a math/physics student], I mean, maybe they didn't see it coming that I would be ... such a nerd." Hence, being a math or physics student implied being associated with a nerd. She outlined the social and cultural storylines by explaining that often the science-focused study programs would be "viewed in a negative light" as other students often would consider them "too nerdy," and that being a woman and choosing a science focus would imply them not interested in science but choosing a science subject only to get access to a prestigious education. Kristi navigated these storylines by countering: "Half of us [students] have chosen it because we think it is awesome." In this sense, Kristi negotiated the alignment between finding the science subjects fascinating and valuing them for their intrinsic worth (like a self-proclaimed nerd), while simultaneously navigating the unconventional position of being a woman in a traditionally male-dominated field. As such, Kristi struggled with combining her gender identity with her math or physics student identity. These negotiations continued when considering future perspectives. Here, Kristi described how a male math or physics student would have a clear educational path:

So, the boys in my class, they all want to be engineers or something like that [...]. I think it's mostly the boys who know for sure because it's also more common for a boy to study math/physics.

As such, the clear educational path was only accessible to the male students. As she saw herself as an odd one out, going against what was normal, she would not have access to the same easy choice of wanting to be an engineer, as this was not aligned with her gender. In this way, her gender identity also conflicted with the math or physics student identity when contemplating the future.

2. Svea

Svea described how she had become more aware of physics as something for her when entering upper secondary school. As physics was taught together with chemistry during lower secondary education, she became aware of how she "lean more towards physics than towards chemistry." She highlighted how she just "generally like stuff

about physics," and that her favorite part was doing experiments as she found the structure meaningful:

I like doing experiments [...]. We start with having some theory, which forms the basis for what we are going to do, and then we do the experiment in the lab, [...] and then afterwards, do some data processing to see if it matches the theory we have learned.

This structure of validating experiments through theory was especially meaningful to Svea as she used mathematics in data processing. She explained how the connection to mathematics was essential and that she could grasp this connection on her own:

You can actually see it yourself when you're working on a physics reports. Like, okay, here, suddenly something with tangent, that you need to calculate this angle [...] so you can sort of draw on that knowledge ... Drawing on knowledge from mathematics into physics to do the calculations.

The connection between mathematics and physics provided her with a way to recognize herself as competent in physics and thereby reproduced the meaningfulness experienced in the structure of learning physics. As such, Svea narrated a sense of belonging by being able to conform to the way physics demanded by following structures to arrive at correct answers while using mathematics.

In relation to mathematics, Svea highlighted that the lesson structure of following the teacher on the blackboard, then "sit and calculate some exercises, so you use and thoroughly scrutinized the formulas and proofs, like you run through it" fit her well. In this way, the responsibility for learning was mainly placed on the students. This structure was highlighted as a way to recognize herself, especially when working "on your own" with assignments: "you have just worked through a couple of assignments, and then suddenly you have this epiphany, like oh, that's how I'm supposed to do it." She acknowledged the increased difficulty compared to compulsory school, but because the goal was finding the correct result, she still found it easy to navigate, perform, and recognize herself within:

If it doesn't match what's in the answer key, then you've done something wrong, and you can look back and go through the process, okay, what did I do here, as opposed to Danish, where there isn't really a definite answer. You just have to analyze it and constantly provide arguments for why what you're saying is correct.

As mathematics offered a way to self-correct when being wrong, Svea contrasted doing mathematics to doing Danish

in relation to instant recognition. In this sense, Svea reshaped her understanding, but as she was able to negotiate, maintain, and develop both her physics and mathematics identity, she experienced continuity and temporal alignment in her disciplinary identity.

Svea did not negotiate her gender identity at this point. On the contrary, she highlighted how in compulsory school she had been recognized in wanting to continue into the upper secondary science study program: “[I] have actually also been told by my teachers in elementary school that they also saw me going in that direction.” In this sense, she was confirmed in her direction toward science. This recognition did not pose a conflict with her gender identity as she concurrently was recognized as a girl fitting into upper secondary school: “I have actually also been told that [the teachers] have always seen me as an STX-girl. Because I was actually kind of good enough at all the subjects and was sort of, all around, above average.” Thus, her gender identity was recognized through being good at “doing school.” As such, she had already been recognized as successfully combining science with “doing girl,” enabling her to transfer this positioning into upper secondary school.

Svea’s narrative can be understood as an example of gendered identity negotiation through alignment rather than resistance. Through recognition by teachers, she is positioned (and positions herself) as an “STX-girl” who is good at doing school, allowing her to integrate science orientation into a culturally recognizable and legitimate feminine identity. Importantly, this early phase of Svea’s identity work is characterized by the absence of narrative disturbance. The available cultural storylines enable a smooth alignment between “doing school,” “doing girl,” and being science-oriented, producing a stable sense of belonging that does not require overt negotiation or conflict. This illustrates how gendered power operates not only through exclusion but also through seemingly smooth forms of recognition that render some identity positions legitimate, easily accessible, and naturally fitting.

B. Second year: Midway through upper secondary school

1. Kristi

In second-year physics, Kristi continued to struggle with conforming and found herself doubting whether physics was for her. She expressed concerns about the difficulty of the subject: “I think it has become more difficult, but it has always been difficult,” illustrating how she created temporal alignment between her present experiences with the subject, altering her past experiences into physics as always difficult. She experienced a widening gap between herself and the teacher:

In physics, I find it quite difficult to understand what [the teacher] is saying. [...] I think he ... is

too clever [...]. He has a bit of difficulty formulating it in a way that we understand because I think he assumes we understand what he’s saying.

The teacher’s cleverness demonstrated a clear distance to her as a student, while the expectation of grasping content intuitively persisted. Kristi explained, like her experiences with first-year physics, how endurance was essential for reaching some kind of understanding.

Additionally, she found her voice was continually unheard:

Sometimes, if you say you don’t understand it, he says that you will understand it in the third year, or that we’ll come back to it later. [...] So it’s like ... right now, there are a lot of loose ends, where you are just thinking, what is really going on.

The lack of acknowledgment and the expectation of accepting a loss of meaning left Kristi frustrated and uncertain about the purpose of learning physics. Her meaning-making processes were troublesome, and she experienced discontinuity. Even when doing experiments, meaning and interests were left out. Instead, a mechanical approach dominated the procedure:

We arrive [at the lab], there is a lab guide, and then you just do it. Sometimes he explains a little beforehand, but otherwise, you just go ahead and do it, and when you’re finished, you leave. [...] Sometimes it just feels a bit long-winded, like you are just writing down numbers for a whole hour.

In this way, experiments lacked a connection to reality and to Kristi’s own interests in physics. Meanwhile, performing the experiments seemed narrow in comparison to doing experiments in chemistry. In chemistry, Kristi described, mistakes were laughed off, creating a safe space, where in physics mistakes were unwelcome: “You don’t make [mistakes] I think, you don’t dare to do that.”

When talking about how to do well in physics, Kristi mentioned knowing “mathematics” as an important factor. Nevertheless, she identified a fundamental prerequisite for doing physics:

I think, just to be able to understand, yes ... like physics, I think. I believe it’s very much about being suited for it. I mean, it’s not ... I don’t know if it’s for everyone.

Hence, she reshaped her understanding of physics as not for her, as she was not able to negotiate and overcome her experience of discontinuity. Her motivation and beliefs about physics as something for her had changed from being interest driven to being extinguished as physics seemed only for the few inherently adept.

Driven by her interests in astronomy and physics, Kristi had chosen an astronomy course in her second year. However, when discussing the course, she distinguished between astronomy as a subject in school and astronomy outside school:

I just love ... I like astronomy and stuff. I look a lot at the stars at home and all that, but it is just a bit boring when [the teacher] talks about it. I think it's the way she teaches us, like, something is like this, and something is like that and ... And you're just sitting there, kind of falling asleep. [...] And then you have to do assignments, but they are just these mindless tasks, where you just have to answer some questions.

Kristi's frustration with the subject of astronomy concerned how there was no room for her own interests and experiences with astronomy. Instead, she experienced an instrumental approach to content and a relegation to the role of a passive recipient of knowledge.

Kristi continued to thrive in mathematics. She explained how she could easily start every morning with a mathematics lesson, as these were always cozy, fun, and nice to participate in, highlighting an inclusive culture. She described how they would often talk about other stuff (e.g., life in general, the stars) during a mathematics lesson. Furthermore, the teacher could incorporate material outside the curriculum because "he could not help himself, he just thought it was amusing." As such, the lessons seemed nonrigid, making her a "want to listen to what [the teacher] is saying and understand it." She described how learning came easily to her: "When [the teacher], introduces us to something new, then I feel, I learn it almost immediately." Meanwhile, having a voice was welcomed: "if I don't understand it, I ask him, and then he is good at explaining what he really means." So, she experienced that the teacher was willing to correct himself and did not fault her if she did not understand. As such, the responsibility for her lack of understanding of the content rested on the teacher's shoulders, not on herself.

In this way, her experiences with learning were welcomed and recognized without a constant need for conforming in a particular way. This highlights how recognition is not merely about evaluation of correctness, but about relational access to the teacher and to valued forms of participation within the discipline.

Even though Kristi thrived in mathematics, she still rejected a future in mathematics:

I mean, I think mathematics is great, but I would be afraid that I would find it boring in the long run if I had to sit and do mathematics every day. [...] No, I could not do that.

Hence, it seemed difficult for Kristi to transfer her enjoyment and love for mathematics into the future, as spending every day only with mathematics appeared to be narrowing. She described how her father had followed an educational path through mathematics. However, she could not see herself in his job situation. On the contrary, she expressed a desire to find "something that I find important" as if the importance of her father's job appeared hidden.

Kristi continued to negotiate her gender identity and her identity as a math or physics student. She expressed how she preferred the lessons with only the math or physics students and not the entire class (including the language students). She described how she had good friends in both groups, but "some of my best friends are the [math/physics] boys." She explained how the language girls could often be "shrill" and "a bit too much," so, she would "rather have a mathematics lesson," which excluded them. She was aware of how her choice of mathematics and physics was seen as nontraditional: "it is more normal for men ... or boys to choose [a math/physics study program]." She experienced a stereotypical and narrow conception of a math or physics student as she described how most would think of them "as nerds who don't have a social life." She contested the social and cultural storylines of the mathematics and physics disciplines as she rejected herself in this conception: "It is not at all correct, because we do, we also have fun." In her negotiation of fitting her gender identity into the math or physics student, she explained how students outside the class could mistake her for a language student, and people outside the school would be shocked when she presented herself as a math or physics student. Finally, she concluded: "maybe it is some kind of compliment that [others] don't think I have math/physics." Hence, it seemed too difficult and undesirable to combine her gender identity with the math or physics nerd identity, as this identity would overshadow her gender identity. As a result, Kristi was not able to fully create a sense of belonging and restricted her identity as a math or physics student to the classroom.

2. Svea

Svea continued conforming to second-year physics based on the structure of the lessons and the close connection to mathematics. For her, getting a theoretical foundation followed by "have[ing] to try to see if you can, well, demonstrate it yourself, or see this connection that exists—not just by looking at it in a formula, but by actually measuring it yourself" was described as "look[ing] at physics in action." So, this structure was meaningful to her, as she considered it engagement with physics. In this sense, Svea conformed to the idea of learning physics as something within the physics classroom. Meaningfulness was likewise found in the application of mathematics in physics. Svea highlighted how this use made mathematics

more “concrete” providing her with an extra dimension when learning mathematics—one not found in mathematics class. She underlined how this use of mathematics would be implicit, making it a form of tacit knowledge in learning physics: “I mean, [the physics teacher] does not say it directly, but he does draw some connections.” This implicit and tacit knowledge did not pose a problem for Svea, as she was able to grasp the connections by herself: “you can probably also see it yourself, because when you are working with it, you are like, okay, I have actually seen something a bit like this before.” As such, the connection between mathematics and physics made learning physics meaningful and also served as a way to recognize herself. Nevertheless, Svea highlighted that to do well in physics, one would really have to want it. So, doing physics required something extra, something that she was unsure if she could give, especially because she doubted herself when participating in class. She explained how participation often required more in physics (than in chemistry) as answers had to be extensive, thorough, and accompanied by a lengthy explanation. Additionally, she preferred to be “100%” sure when participating:

I think I have a hard time conveying it to others, like, okay, I maybe understand it when I sit and look at it myself. But when I have to actually say it out loud, I’m not quite sure how to communicate it, because I don’t understand it like 100%.

Thus, for Svea, participating meant being 100% sure and doing 100% correct. As such, participation was deemed difficult and sometimes impossible. This self-view was furthermore underlined in how she expressed that participation in general had never been her strong side:

I have never really been one of those who raise their hand. So, I think it’s just a continuation from elementary school, where I was not one of those who raised their hand.

This retrospective positioning can be understood as a narrative strategy through which Svea retrospectively stabilizes her identity, making emerging participation difficulties appear continuous and unsurprising rather than contingent and situational. What appears as a personal characteristic (“I have never really been one of those”) functions narratively to stabilize her identity in a situation where recognized forms of participation increasingly diverge from her ways of engaging. At the same time, this marks the beginning of a narrative disturbance. The previously smooth alignment between “doing school” and being recognized as competent becomes fragile, as valued forms of participation increasingly privilege outspoken, confident, and risk-taking performances. In this sense, Svea’s identity negotiation shifts from alignment to uncertainty, as the conditions for recognition change within the

disciplinary context. Importantly, this disturbance is gendered. As recognized participation increasingly aligns with what can be considered masculine practices, such as speaking loudly, displaying confidence, and taking risks, Svea’s previously legitimate position as a “good student” becomes less secure.

However, Svea’s love for mathematics kept expanding. She explained how the structure of starting with the teacher explaining at the blackboard, then doing assignments, continued to suit her well. She highlighted “the one correct answer” as the primary reason for thriving when learning the subject, but also how the process of having a theory, using a formula, and finding the correct answer made mathematics concrete opposed to abstract. As such, this search for the correct answer seemed meaningful to her. She emphasized “self-discipline,” “working on your own,” and “independence” when describing what was needed when doing mathematics. Hence, the responsibility for learning continued to be placed on the students:

We are very independent; it is us that makes things happen. [...] Because we are the ones that makes the assignments, eh, and like have to ask questions if there is anything. [...] Like our teacher, he is not the type that keeps a close eye on everyone, it is very much about doing it yourself and then asking if you need help.

Thus, learning mathematics was an individual task, driven by the ability to complete assignments and identify when to ask for help.

Even though Svea saw herself as fitting in both mathematics and physics, she saw an undefined future within physics and mathematics:

But I don’t think I’ve really looked into it enough, because I don’t really know what you can actually do, like, what you can become with Physics, and also with studying Mathematics.

So, seeing herself in the future studying either physics or mathematics seemed diffuse, with unclear potential outcomes. This uncertainty worked as a barrier because she could not see herself in the future, and constructing a viable identity seemed essential for imagining herself in the future:

It is very much about following your own interests, trusting your gut feeling and, yes, really feeling what you’re passionate about, rather than just choosing something everyone else picks or going with what seems easiest. It’s about choosing something where you feel true to yourself

In this way, it seemed difficult to transfer the identities in physics and mathematics into the future.

At this point, Svea began to negotiate her gender in relation to participation. Focus grew on her oral participation at the board, where she lowered her expectations for herself in fear of being disappointed. For her, mathematics and physics were where she felt most competent, yet she simultaneously experienced the highest level of insecurity. She explained that in some STEM-related subjects, what was recognized was being outspoken and loud to show off one's abilities. This behavior, she underlined, was: "primarily some of the boys who do it." Those who were good at mathematics were often those who "believe in it." In this sense, she was aware that displaying abilities could be advantageous, and that male students, as opposed to female students, appeared more confident in showcasing their skills. As such, Svea began doubting herself as her gender identity as "doing good student" was difficult to combine with the outspoken and loud performances that were recognized in the STEM-related subjects.

C. Third year: Final year of upper secondary school

1. Kristi

In the third year of physics, Kristi no longer talked about having interests in physics but instead expressed how she struggled with seeing herself in physics. The disturbance became so significant that she reconnected with herself and was not able to negotiate any sense of belonging. She emphasized listening to the teacher as a key competence and how asking the teacher for explanations would be beyond consideration, as he would answer: "like you ought to know that and read the book." In this way, the expectation of intuitively understanding the teacher persisted into her third year, while the responsibility for one's own learning was solely placed on the students. Kristi stated: "I don't think he has any responsibility for us doing what he says we should." Consequently, she ended up doubting herself:

[The teacher] also says something like: "you have to remember it because I'm not going to teach it to you again." And then if you can't remember it, you feel like you haven't learned it at all.

So, not being able to conform to and meet the narrow expectations made Kristi doubt herself. Her solution to this situation was to endure and try to conform even more: "I think like ... I don't know, listen some more [...] and really insist on pulling yourself together [...] or else it will bite you in the ass." As such, Kristi internalized her sense of not fitting in, making herself feel guilty: "I think it's just about me pulling myself together."

The only way Kristi could counter her self-doubt about fitting into physics was by drawing on her competencies in mathematics: "So, if we do things, that is how it is, sometimes we have to use mathematics or something we learned in mathematics, which I know how to do, and then

I think I just feel a little more that I also can do physics." In this way, being competent in mathematics worked as a way to feel a small degree of competence in physics. However, drawing on mathematics was not enough to maintain Kristi's physics identity. Conversely, Kristi decided to get help with physics from outside the school, as she wished to improve her grades. As such, the school context forced her to engage with the subject in an instrumental and detached manner, while her prior physics identity disappeared.

Kristi continued to thrive in mathematics during her third year as she experienced continuity and temporal alignment. She described: "I just think mathematics is great [...] I know how to do it [...] it's just fun." She explained how she saw herself as "very logical minded" and that she had always been good at it. Hence, her current feeling of fitting in validated her prior experiences with the subject. She highlighted how she liked it when "inside my head it all makes sense." So, she was able to recognize herself through the experience of things making sense. She described how the increasing difficulty through the three years and the structure of constantly "building on top" suited her well. These elements even help her recognize herself as competent: "So, when you are constructing a proof, you can just say that I do this, because I know this from first year. [...] It is one of those subjects where I can remember everything." In this sense, being expected to use her prior knowledge strengthened her confidence in her competencies and in her sense of fit. Meanwhile, the teacher recognized Kristi as a learner for whom he held a responsibility, as the teacher would talk "with" them instead of "to" them. She explained how they would often have a dialogue with the teacher in contrast to the teacher "just standing there preaching."

Kristi continued to align herself with being brainy and having natural ability when describing doing mathematics:

There are some people who don't have the same mindset as I do [...]. I guess, I just have a different mindset than some of my other friends who are in the humanities, who know how to write a long Danish paper and things like that. I don't know how to do that.

Kristi's emphasis on natural ability can be understood as drawing on dominant cultural storylines of mathematics, where competence is closely tied to ideas of brilliance, logic, and innate talent. Importantly, this does not imply that such narratives are inherently masculine in themselves. Rather, within mathematics, these storylines have historically been gendered through repeated practices of recognition that align "real" mathematical competence with masculine-coded performances. While this positioning enables Kristi to be recognized as a competent mathematics student within the classroom, it simultaneously reproduces narrow and exclusionary criteria for belonging, making mathematical identity contingent on access to these

celebrated forms of competence. Through this positioning, Kristi continued to differentiate between being a “math person” and a “humanities person,” where the former was understood to require a particular mindset. The way mathematics was practiced thus nurtured her mathematical identity and reassured her in her sense of fit within the subject, allowing her to negotiate her mathematical identity without experiencing narrative disturbance at this stage.

Kristi continued to struggle to unite her gender identity with learning physics. She described how she was convinced that the physics teacher viewed her differently compared to her male classmates:

I just feel like my physics teacher doesn't like me. [...] I just feel like I'm doing exactly the same as the boys do [...] I just have this feeling that it's the way he looks at us. [...] I feel like he generally likes the boys much better. [...] I just think that some of the boys are his favorites, or however you'd put it. They ... like they know how to, they're much better at talking to him and joking with him. I just can't do that, and I just find it annoying that it will impact my academic assessment.

Kristi's frustration centered on how gendered patterns of interaction distanced her from her male classmates and the male teacher, excluding her from having the same relational access to the teacher as her male peers. This experience marked a narrative disturbance in Kristi's engagement with physics. While she continued to invest effort in and participate on similar terms as her male classmates, she perceived that recognition operated differently, rendering her participation less visible and less valued. Importantly, this disturbance was not rooted in a lack of interest or competence, but rather in disciplinary practices of recognition that privilege informal interaction, ease of joking, and relational proximity to the teacher, forms of participation that Kristi experienced as less accessible to her. This co-produced Kristi's sense of belonging in physics as fragile, illustrating how gendered patterns of recognition shape who can be seen as a legitimate and valued learner within the disciplinary context. In this sense, her gender identity hindered recognition as a valuable learner in physics. The emphasis on the structures was furthermore highlighted in how she described her own advantages when learning Danish:

In Danish, and stuff like that, I think my teachers might be more... I have a sense that [the Danish teacher] is more inclined to think that the girls are better at Danish than the boys are. [...] I feel like [the humanities teachers] are more ... because stereotypically it's the girls who are best at it. [...] It only works to my advantage, though, because I'm not good at it. [...] I also think it might have

something to do with the fact that [the Danish teacher] is, you know, a woman, and somehow I ... I don't know, I don't know ... I find it easier to bounce ideas back and forth with her than [the boys] do.

So, being a woman made it easier to connect with a female teacher, but it was also difficult not to be recognized as a valuable learner in the humanities subjects even without making an effort for it. As such, she experienced gender (her own and the teachers') as essential in how she was assessed and recognized by the teachers. It highlights how belonging is not tied to gender itself, but to how disciplines organize recognition and participation.

2. Svea

By the third year, accumulated moments of disturbance had shaped a more stable narrative orientation, influencing how Svea anticipated her future within the discipline. Her self-doubt about her oral performance in class and exams continued to grow, reinforcing a sense of never having truly fitted into school. As a result, she lowered her expectations for grades in mathematics and physics and internalized insecurities about participation, ultimately weakening her confidence in continuing within the educational system.

Svea maintained her strong interest in physics. She described how this interest was based on the close connection to mathematics and that the use of mathematics gave meaning to learning physics. Furthermore, she could transfer her knowledge of formulas and competencies from mathematics into physics. However, physics had become more difficult, and the premises for participating required conforming to the culture even more:

I think, first of all, you really need to stay sharp, because there is a lot to keep track of, and there is a lot of theory. Uh. There is also a lot of theory compared to what there is in other subjects. Um. So, you need to persevere, because sometimes it can be an entire lesson of theory, where you might find yourself thinking a bit, okay, I'm a bit lost. So, you really have to pull yourself together in those lessons.

Conforming to the culture of learning physics was not easy and straightforward; it required strict attention, dedication, and tenacity. She emphasized a need to “really like it and really being interested in it,” underlining a special effort that needed to be included in physics. As a result of this conforming, exploring reality became identical to doing lab experiments:

And I think that's what I really like about Physics, the fact that you get to work with what you are learning and actually see how it works in reality.

[...] So sometimes he talks about which experiments we are going to do, and there is also a purpose, and some data processing involved, where the purpose is often to investigate some law, or to verify it, yes, to show that Newton's second law holds.

In this sense, reproducing knowledge by verifying theories learned seemed meaningful and purposeful. However, this way of doing physics made physics into something reserved for the physics classroom and thereby not related to the outer world.

Svea continued her love for mathematics in her third year. Here, meaning-making was at ease, and she described it as her favorite subject, where she felt most confident and secure in herself. Svea highlighted how the search for the one correct answer made it "concrete" and "easy to relate to." She contrasted learning mathematics with learning Danish and described how interpretations and argumentations in Danish made it difficult to determine when you performed correctly. On the other hand, "in mathematics there is a like one answer. So, if you don't give that correct answer, then you know you have done something wrong." As such, it was easy to identify when you were wrong, and thus it was equally easy to determine when you were right. In this sense, it was easier to recognize oneself as correct or wrong before performing and risk nonrecognition by the teacher and fellow students.

When discussing the level in her class, Svea differentiated the students according to speed:

Like it is always the same who finish with the assignments fast. So, you can sense that there are those who accomplish two, three assignments per hour, and then there are those who accomplish many assignments in an hour.

Hence, completing assignments quickly was a way to be recognized. Svea underlined how she would often be one of those who told the teacher that she "was done with the assignments and then get extra assignments" from the teacher. In this way, doing it fast and alone provided a way for her to be recognized in class. This way of doing mathematics fast and alone reinforced the independence and responsibility of the students: "I think it is most pleasant to do assignments, because then you can sort of work with it on your own and that is properly how it sticks [to the brain] the best." As such, the responsibility for learning continued to be placed on the students. This responsibility seemed heavy to bear, and she dismissed the idea of pursuing mathematics after upper secondary school, as she believed it would demand too great a level of independence: "I think I would fall behind because it's a lot sitting with the head in a book and read, um, and a lot of self-studies, having to learn it yourself." In this way, learning mathematics required conforming and adapting

in such a way that it seemed difficult to transfer this identity out of the context.

Despite her love for mathematics and how she could be recognized and recognize herself, Svea still doubted herself and her performance, especially when performing in class and at oral exams. She explained how her self-doubt was especially related to potentially saying something wrong and how this seemed different for the male students:

I have a huge insecurity. Like saying something that might not be correct, uh, and I think maybe boys don't have it as much. They just raise their hand because they have something to say, and then they take the chance.

Svea's classroom participation was shaped not only by her role as a student but also by her gendered position. For her, participating as a male student appeared smooth and risk-free. In contrast, her own participation involved constant anticipation and self-monitoring—"thinking ahead" about the consequences of being unable to answer. As such, it was difficult for her to move away from "thinking ahead" and being responsible, structured, and hard working, even as she recognized that more risk-taking forms of participation were valued.

D. Kristi's and Svea's swimming and sinking during upper secondary

We set out to understand why two students—Kriti and Svea—who left compulsory schooling with strong physics and mathematics identities, completed upper secondary school with level A in both subjects, but did not evolve and flourish strong disciplinary identities that enabled positive choice considerations for a future in STEM. While Kristi's earlier alignment in mathematics remained largely intact, her experiences in physics solidified with sustained discrepancies (see Fig. 1). For Svea, her third-year participation increasingly confirmed earlier uncertainties, creating discrepancies rather than opening new possibilities for alignment (see Fig. 2).

Taken together, the analyses over time illustrate how disciplinary identities are shaped not by isolated moments, but by how recognition, participation, and meaning-making unfold over time, gradually opening or closing possibilities for belonging and continuation. In this process, recognition operates through sedimented patterns of being seen, overlooked, or addressed differently, shaping a sense of belonging. These sedimented patterns gradually stabilize not only participation but also what futures can be plausibly imagined, rendering alternative trajectories increasingly difficult to narrate as realistic or desirable. As a result, future orientations emerge not as individual preferences, but as narrative outcomes of prolonged alignment or disturbance within disciplinary practices.

We employ the metaphor of *swimming and sinking* to synthesize ongoing efforts to maintain narrative temporal alignment and belonging over time. This metaphor functions as an interpretive illustration of the identity negotiations and captures how disciplinary identity work unfolds narratively over time: not through sudden turning points, but as continuous processes where sustained narrative alignment enables continuity, while repeated disturbances undermine belonging and erode future-oriented narratives.

Across the two subjects, Kristi's and Svea's trajectories reveal contrasting patterns of swimming and sinking. Kristi initially experienced narrative alignment in both physics and mathematics. Over time, however, physics became a site of sinking. Narrow norms of participation, limited recognition of her interests, and an individualized responsibility for learning displaced her sense of herself as a legitimate physics student. Physics increasingly appeared as a domain that demanded conformity to a specific culture and innate ability, pushing her further away from the subject despite sustained effort and interest. By contrast, she sustained swimming in mathematics through consistent recognition and alignment with the discipline's celebrated forms of competencies and performances. Importantly, this swimming did not necessarily signal openness or inclusivity, but rather a close fit with Kristi's ideas of "doing school" and the discipline's norms, and thus it nurtured her sense of self as being mathematical. Nevertheless, the sense of swimming was difficult to extend beyond the classroom. By the end of upper secondary school, Kristi struggled to imagine herself inhabiting a future mathematics or physics identity.

Svea's negotiations portray a different process of swimming and sinking. Throughout upper secondary school, she largely managed to swim by conforming her disciplinary identities in both physics and mathematics to the new culture in upper secondary school. In physics, this involved treating the subject as meaningful due to the experimental work and the applications of mathematics. However, in the final year, she realized that conforming to expectations placed substantial demands on her, as physics seemed increasingly detached from broader relevance. Maintaining alignment no longer felt sustainable. She ascribed a fast pace and overwhelming independence to mathematics. Importantly, the absence of discrepancies does not necessarily indicate openness or inclusiveness. Over time, the narrative alignment became more demanding. During the three years of upper secondary school, her gender identity was reduced to performing well and being good at school. However, she found it difficult to combine this with being recognized in the STEM-related subjects. Disturbances intensified and led to constant self-monitoring, which again resulted in emotional costs. Swimming became more difficult. Over time, she began doubting herself: She felt the need to be certain before she spoke, while her male peers engaged more spontaneously. This shift changed her

self-perception from being good at "doing school" to doubting her abilities, ultimately reducing her confidence in continuing within the educational system. By the end of her upper secondary education, her diminished confidence left her feeling unsure about pursuing a future within the broader educational system, including STEM.

Kristi's and Svea's negotiations illustrate that disciplinary identities are not simply weakened or sustained by individual interest or motivation. Rather, they are produced relationally through participation structures, recognition practices, and the kinds of selves that are made narratively viable within each discipline. Throughout the three years, Kristi's and Svea's negotiations illustrate how disciplinary identity work unfolds through shifting conditions for recognition. While both women initially experienced alignment with physics and mathematics, repeated disturbances in some contexts and sustained alignment in others gradually shaped what forms of participation, belonging, and future orientation were narratively viable.

Thus, swimming and sinking are produced relationally through participation structures, recognition practices, and the kinds of selves that are made narratively viable within each discipline [see also Ref. [13]]. The "sink or swim" culture thus not only operates as a pedagogical arrangement but also as a narrative mechanism: It individualizes responsibility for understanding and success, rendering difficulties intelligible as personal inadequacies rather than as effects of disciplinary organization. These experiences gradually position learning as an individual responsibility, where difficulties are framed as personal shortcomings rather than as effects of disciplinary organization [56].

Both Kristi and Svea did well on their physics and mathematics final exams at the end of their upper secondary education—a fact that surprised them both. Kristi expressed how the exams "exceeded all expectations" and that she managed to graduate with the grade point average she had hoped for. Nevertheless, academic success did not alter their uncertainty about future educational trajectories. Seen through the metaphor of swimming and sinking, this highlights a central paradox of upper secondary STEM education: Students may continue to "swim" academically while simultaneously sinking in terms of belonging and future orientation.

V. DISCUSSION

This paper illuminates students' longitudinal identity negotiations within physics and mathematics throughout upper secondary school. Central to our analysis is the concept of disciplinary and celebrated identities, which we have integrated with perspectives from narrative psychology. This theoretical lens has allowed us to explore how narratives, as shaped and negotiated over time within broader axes of recognition practices and power, frame certain storylines as more accessible, achievable, and meaningful. Our analysis is based on data from a

longitudinal qualitative study involving 32 young women in upper secondary school. For this paper, we have focused specifically on two students, Kristi and Svea, who exemplify a paradox: Despite entering upper secondary school with strong science and mathematics identities and pursuing advanced coursework in both subjects, they consistently refrained from considering futures in STEM. Thus, our analysis sheds light on how gendered identities and power dynamics influence young women's trajectories in these traditionally male-dominated fields. Through a reflexive thematic analysis [54,55], we have examined the (dis)continuities, alignment, and disturbances within their narratives to explore how they formed and negotiated their disciplinary identities over time in relation to physics and mathematics. To illustrate these processes, we have employed the metaphor of swimming and sinking to illustrate the identity work of the two women—highlighting their efforts to swim by maintaining, developing, and negotiating their identities, even as they struggle and feel themselves sinking. Considering that Kristi and Svea transitioned from compulsory school with strong science and mathematics identities and continued to pursue an advanced level in physics and mathematics, it is evident that upper secondary school physics and mathematics failed to support, nurture, and fully realize the two women's potential within the subjects. In this discussion, we will reflect on the elements that challenged and, in the end, prevented the young women from shaping sustainable disciplinary identities within physics and mathematics. We have identified several contributing factors, ranging from structural, disciplinary, and cultural factors, discussed in the Secs. VA–VE, followed by the implications of this study presented in Sec. VF.

A. Gendered narrative discontinuities of not being associated with privilege

Conceptually, this paper advances research on diversity and inclusion in STEM by showing how disciplinary identities are shaped through sedimented practices of recognition over time. Rather than locating young women's disengagement in individual dispositions such as confidence or motivation, the findings highlight how gendered power relations are enacted through everyday disciplinary norms, shaping whose participation, interests, and futures become intelligible and valued. We have shown the interplay between gender and the demand to conform to fit in and align oneself with the disciplinary norms and practices of physics and mathematics. This was evident, for example, when Kristi encountered disturbances in her narrative when striving to integrate her personal interests in physics and astronomy. Across upper secondary school, she eventually stopped talking about these interests altogether, as she struggled to see them as legitimately part of the discipline. Consequently, she came to see her interests as being in conflict with the subject matter and left that part of herself

outside the classroom. As such, the lack of recognition of interests as relevant and meaningful influenced the possibilities for forming a sense of identity within the subject. This means that “what” is recognized and celebrated in the learning situation is closely tied to “who” is recognized and celebrated. From a diversity perspective, this illustrates how inclusion is not only about access to participation but also about whose interests and ways of making meaning are ascribed value and rendered legitimate within disciplinary practices [13]. We argue that such narrative discontinuities in identity work are gendered, as those who are not inherently associated with privilege in the context (in this case, young women in physics) face the risk of challenging normative expectations when attempting to align themselves and their interests with classroom practices. These exclusions of interests echo prior research and show a need for female students to align themselves (and their interests) with the subject as it is presented in teaching situations [57,58].

B. Disciplinary identities and bonding with the teacher

We now turn to the discussion about why Kristi and Svea struggled to be recognized as valuable learners and the consequences. Throughout their three-year upper secondary education, Kristi and Svea negotiated various aspects of their disciplinary identities in mathematics and physics. A central aspect of this negotiation revolved around their experiences with student-student recognition practices, particularly concerning who is celebrated and recognized as a “real” student in physics and mathematics. For example, recognition by peers as a math or physics student was contingent on being perceived as a passionate and clever physics person without social skills—a “nerd” in physics [see also Refs. [59,60]]. Similarly, in mathematics, (self-)recognition was tied to the perception of possessing innate ability, emphasizing mathematical competence as belonging to a selective group of students [see also Ref. [61]]. This highlights how recognition and disciplinary identity in physics and mathematics are shaped by social perceptions and exclusivity. Recognition here operates as a relational and cultural resource, unevenly distributed through informal bonding, humor, and shared backgrounds, thereby functioning as a subtle but powerful mechanism of inclusion and exclusion. It also aligns with prior research showing that these subjects are associated with male, White, and middle-class identities [10,11,62,63].

Another key aspect is related to the cultural aspects of the discipline. Here, Kristi highlighted how “bonding with the teacher” is easier to establish for students affiliated with the teacher's background. Bonding allows students to approach the teacher informally: They can make jokes with the teacher and get access to help [30,57]. Establishing such informal relationships with the teacher appears to be

particularly important when students' backgrounds differ from that of the teacher. For example, Den Brok *et al.* [64] show that establishing such a relationship is more important for non-Dutch students than for Dutch students. The authors suggest that this might be associated with a feeling of having to adapt to the hegemonic cultural setting of the classroom, and that the effort for minority students is much higher than for Dutch students. As a result, minority students risk experiencing a loss of identity. The authors call for teachers to widen what and who they acknowledge and recognize to include a variety of ways of participating [64]. In this study, we found a similar hegemonic pattern in the classroom where the young women's narratives illuminate masculine practices of being logical and rational; working individually and prioritizing speed; being outspoken and a risk-taker, and being successful due to innate talent [see also Refs. [10,65]]. Kristi perceived this "bonding with the teacher" as achievable in mathematics. In her experience, the teacher created a safe, inclusive environment by engaging "with" the students rather than merely speaking "to" them. This highlights the potential for building connections and ensuring accessibility for all students, regardless of differences in background. However, it is important to note that Kristi drew on her "innate talent" in mathematics to align herself with the "real" mathematics student. As such, recognition remained tied to these narrow and limited positions.

C. Negotiation paradox: Being a good student or a physics student

This leads to the third aspect that relates to the disciplinary practices of physics and mathematics. In both subjects, the aforementioned masculine practices are not unique to our context, as they are echoed in prior research [65–68]. These practices imposed significant constraints on both women's identity work, forcing them to negotiate their gender. Svea, for instance, struggled to maintain her gender identity as a "good schoolgirl"—being responsible and structured—while simultaneously being outspoken and taking risks in the subjects. These negotiations of combining gender identity with a physics identity closely resemble the findings by Carlone [34], who observed young women in upper secondary school navigate their identities within a reform-based physics classroom. In that study, the young women prioritized preserving their "good student" identities. In our study, Svea's negotiation resulted in self-doubt on both fronts—"doing mathematics and physics" and "doing school." This tension produced a fragile sense of competence, not as an individual shortcoming, but as an effect of negotiating incompatible expectations of what it means to be a "real" student in the discipline [see also Ref. [69]]. These findings can help shed light on the internalization of practices that create self-doubt for women identified by other researchers [23,70]. Kristi was similarly compelled to negotiate her gender, as she found the math or

physics student identity too narrow and inconsistent with her narrative-identity practices outside of the classroom. Other studies have identified similar tensions, where women navigate these conflicts by suppressing aspects of their gender identity, such as being less "girly" [71]. In our study, Kristi negotiated this tension by confining her disciplinary identity in the subjects to the specific context of the classrooms. Consequently, this disciplinary identity in mathematics and physics appeared difficult to extend to and align with other settings, including her future aspirations.

D. Outsiders on the inside

Seen through the lens of narrative negotiations, swimming and sinking captured how alignment and discrepancies accumulate over time, creating disturbances and shaping which disciplinary identities remain narratively viable. Across the three years, Kristi's and Svea's trajectories illustrate how sustained alignment in some disciplinary contexts can coexist with repeated discrepancies in others, gradually reshaping their sense of belonging and future orientation. Collectively, the above aspects illustrate how Kristi and Svea struggled to reconcile their gender identity with the "celebrated" student identity in the subjects, shedding light on how disciplinary settings can unintentionally create barriers to participation and identification. Their struggles underscore how identification with masculine subjects [see also Refs. [65,71]] can conflict with the constructions of femininity [10,72,73], "marking" them as different—both among other young women and within the "mathematically able" group [74] (p. 716). These challenges had profound consequences for their ability to maintain an identity in the disciplines, as they experienced discontinuities and disturbances in their narratives. This made it difficult for them to align their past aspirations with their present experiences, ultimately leading them to question whether the disciplines were truly for them. As a result, Kristi and Svea felt like outsiders, even when they were physically present within the domains of physics and mathematics. This illustrates how power in disciplinary settings operates not primarily through exclusion from participation, but rather through shaping who can plausibly see themselves as belonging and continuing within the field [13].

E. Addressing the "sink or swim" culture

Turning to the last set of contributing factors in how upper secondary school physics and mathematics failed the two women, we now discuss the teaching cultures and learning possibilities within the subjects. In both subjects (especially for Kristi in physics and for Svea in mathematics), the established practices shifted the responsibility for learning from the teacher to the students entirely. This created a "sink or swim" culture, where students are expected to take responsibility for their own success [75].

Analytically, this sink or swim culture functions as a narrative mechanism that individualizes responsibility for learning, obscuring how disciplinary practices distribute recognition and support unevenly, and thereby shaping who can risk new forms of participation and identity. Consequently, if students do not perform well, the blame falls on them, reinforcing the perception that they are simply not suited for the subject. This creates a conception of physics and mathematics as something you are either naturally skilled at or not [56]. Furthermore, this culture demands that the students already possess the necessary resources and know how to use them within the classroom—for example, already have an interest in the subject and the ability to demonstrate it, or to excel at communicating and effectively showcase this skill related to the subject [75]. In reality, this means that the students can be forced to take responsibility for parts of the internal didactic transposition [76]. In this study, this meant that Kristi and Svea adapted and contextualized the knowledge to teach themselves. As a teacher, falling short in being responsible for the didactic transposition and overlooking the need to make complex knowledge more accessible can have serious consequences for the students, especially since the shift from compulsory school to upper secondary school in, for example, science emphasizes a scientific purpose that progressively becomes decontextualized from everyday interests [14]. This makes students depend on the teacher to foster and nurture an appreciation for the scientific purpose behind science learning, as many students struggle to develop this appreciation spontaneously [3,14,28].

From a diversity and inclusion perspective, this highlights that inclusive teaching is not primarily about adding support for particular groups of students, but rather about reconfiguring how responsibility, recognition, and meaning-making are organized within disciplinary teaching practices. Rather than targeting individual learners, inclusive teaching can be understood as addressing the conditions under which participation and competence become narratively recognizable. One example of instructional support that can foster more gender-inclusive teaching and broaden how disciplinary competence and participation are understood is the following two-part exercise.

Phase 1 involves making expectations and norms explicit (inspired by Ref. [77]). The teacher initiates a whole-class discussion in which students collectively brainstorm characteristics of a “good physics student.” Their contributions are supplemented by the teacher to develop a shared framework. By articulating and bringing into the open some of the assumptions held by students and the teacher, the activity creates a reflexive space in which normative expectations can be examined and discussed. While shaped by existing power relations, this reflexive moment nevertheless opens possibilities for questioning taken-for-granted forms of recognition. Following the discussion,

students are invited to reflect on their own engagement with physics in relation to the jointly articulated dimensions, while the teacher conducts a parallel reflection on how students’ participation and competencies become visible in classroom interactions. These reflections form the basis for student-teacher conversations that focus on contrasts in perceptions and strategies for further development. In this way, the activity supports inclusion by encouraging critical reflection on normative expectations and by presenting physics as multifaceted and learnable.

Phase 2 (inspired by Ref. [28]) focuses on the teacher’s recognition patterns. Students anonymously complete a questionnaire about what they perceive the teacher recognizes or praises during lessons. The teacher responds to the same questionnaire, indicating what they believe they celebrate and recognize in the classroom. Contrasting these two sets of responses enables the teacher to reflect critically on their own recognition practices and provides a foundation for dialogue with students about what is valued in the classroom. Taken together, the two phases offer students an opportunity to uncover and discuss expectations while giving the teacher a structured space to examine their own patterns of recognition.

Importantly, such expectations and recognition practices are not always visible to either teachers or students. For this reason, collegial reflection and peer observation can play a crucial role in supporting more inclusive teaching practices. Structured collegial dialogue, guided by shared prompts, can help make patterns of participation and recognition more explicit. For example, a colleague observing a lesson might attend to questions such as: Who is invited to speak, and who takes the floor spontaneously? Whose contributions are taken up, extended, or interrupted? Which experiences, forms of reasoning, or modes of engagement are recognized as legitimate? These prompts are not intended to produce definitive answers, but rather to support reflective dialogue about how disciplinary norms and recognition practices are enacted in everyday teaching. In this way, collegial observation becomes a tool for collective sensemaking rather than surveillance, enabling teachers to reflect on how participation structures and recognition practices may unintentionally reproduce exclusion, and how alternative forms of engagement might be supported over time.

In sum, the findings suggest that fostering diversity and inclusion in STEM requires attention not only to who participates but also to how disciplinary teaching practices shape recognition, responsibility, and the kinds of identities that can be sustained over time.

F. Implications

The outcomes of this research point to important implications for teaching practices, school organization, and educational policy. Our aim is not to assign blame to teachers but rather to highlight the underlying axes of

power that influence and shape their practices. Nevertheless, it is important to recognize that the classroom culture is not solely shaped by teachers. Broader educational policies and managerial structures also impose constraints on both teachers and students [66].

1. Implications for teaching

Building on the students' narratives in this study, our findings further suggest that inclusive teaching in physics and mathematics requires instruction to be meaningfully connected to students' lived experiences, interests, and available resources. When disciplinary teaching is framed exclusively from the perspective of the subject (its internal logic, pace, and valued practices), students are implicitly expected to adapt themselves to the discipline. As illustrated by Kristi's and Svea's narratives, such expectations can produce disturbances when students struggle to see how their ways of engaging, interests, or identities can be recognized as legitimate within the subject.

Inclusive teaching, therefore, involves didactic work that moves beyond one-directional transmission of disciplinary content and instead attends to how teaching can be *responsive* to learners. Drawing on students' questions, interests, and prior experiences does not imply lowering disciplinary standards. Instead, this approach supports students in negotiating meaningful entry points into the subject. Such an approach can help mitigate "sink or swim" dynamics by making participation less dependent on preexisting familiarity with disciplinary norms and more accessible to a broader range of learners.

From this perspective, structured and dialogic teaching practices where expectations are made explicit, multiple forms of participation are legitimized, and students are supported in connecting disciplinary content to their own sensemaking can play a key role in sustaining students' sense of belonging over time. As argued by Tanner [78], structured approaches that are responsive to learners' resources can support broader participation and enable students to engage without distancing themselves from who they are in order to be recognized as legitimate learners. Inspiration can be found in Archer *et al.* [79], who propose transforming science pedagogy to become more culturally sustainable by broadening what counts in the classroom. This includes expanding the boundaries of what is considered part of the subject's disciplinary content and practices. Moreover, Bøe [80] advocates for redefining what achievement means (e.g., more than providing the correct answer) to challenge and reshape the perception of what it means to be a good physics student. Finally, Good *et al.* [81] propose initiatives aimed at supporting more students in feeling recognized in physics. They suggest rewarding various steps in the problem-solving process, rather than focusing solely on the final product or outcome. By acknowledging multiple forms of participation, these

approaches help include a more diverse range of students and foster (gender)-inclusive teaching.

2. Implications for schools

At the school level, it is key to create organizational conditions that support sustained pedagogical reflection. Inclusive teaching cannot rest on individual teachers alone. It requires time and structures for collegial dialogue, including opportunities to make often tacit exclusions visible through shared observation and discussion of classroom practices, and collective reflection on whose participation is enabled or constrained. Professional learning communities and collegial sparring can support teachers in identifying how disciplinary norms and recognition practices may unintentionally reproduce exclusion and in experimenting with alternative ways of organizing participation and assessment.

3. Implications for policy

At the policy level, efforts to promote diversity and inclusion in STEM education should move beyond recruitment strategies and deficit-oriented explanations that position young women as lacking confidence or resilience. Instead, policymakers and educational leaders should attend to how teaching and learning practices shape recognition habits. Supporting inclusive STEM education requires systemic investment in teacher education and continuing professional development that foregrounds didactic transposition, recognition, and belonging as central pedagogical concerns.

For instance, in the study context, Danish upper secondary school teachers are educated within academic disciplines, rather than through dedicated teacher education programs. This approach may significantly impact their awareness and knowledge of transforming complex disciplinary knowledge into effective teaching practices for upper secondary school students. The focus within academic disciplines tends to be more theoretical in nature. As a result, less attention is given to the practical transformation of knowledge for teaching purposes. We advocate for critical reflection on how to foster (gender)-inclusive teaching practices already in teacher education programs. Finally, we echo the call from Archer *et al.* [13], urging teachers, educational decision makers, and policymakers to move away from describing young women as lacking confidence in physics and mathematics. Instead, we propose understanding their feelings of not being clever enough as a product of the field itself—shaped by factors such as the disciplinary practices in school physics and mathematics—rather than as an individualized or gendered deficiency.

While this study has analytically foregrounded identity negotiations with a particular emphasis on gender, we recognize that identity work in physics and mathematics is shaped by multiple intersecting social categories, including

social class, ethnicity, and educational background, among others. Our longitudinal design enabled us to trace how narrative negotiations of belonging and recognition unfolded over time; however, future research would benefit from explicitly examining how intersectional negotiations become stabilized, recede, or are reconfigured across educational transitions. From a narrative perspective, intersectionality is not only a matter of multiple social positions; it also concerns how different axes of identity become narratively salient, available, or muted at particular moments. Therefore, intersectionality represents an important next step for longitudinal identity research seeking to understand how multiple axes of difference interact with disciplinary practices of recognition over time.

VI. CONCLUSIONS

In this paper, we have strived to understand the paradox of why young women who entered upper secondary school with strong science and mathematics identities and pursued advanced-level courses in both physics and mathematics yet consistently refrained from considering futures in STEM. We conducted a longitudinal study to explore the complex disciplinary identity work of two young women, Kristi and Svea, in the context of upper secondary school physics and mathematics. This approach allowed us to analyze how teaching practices, along with structural and cultural factors, influenced their experiences. Our findings revealed that these factors together discouraged the two young women from maintaining sustainable narratives. First, Kristi and Svea faced substantial challenges in aligning their gender identity with the dominant perception of the “real” student identity in physics and mathematics. Furthermore, their interests outside the disciplines remained disconnected from physics over time. Moreover, the analysis revealed that facing narrative discontinuities was a gendered experience: Young women in physics and mathematics, lacking inherent privilege in this context, risk

breaking normative expectations if they attempt to align their identities and interests with classroom practices. Second, we found that bonding with the teacher is important for maintaining identities, yet such bonding was restrained through the application of narrow masculine strategies. Finally, teaching practices characterized by a “sink or swim” culture amplified their sense of inadequacy and unfitness for these disciplines.

The study contributes to addressing the challenge of opening the fields of physics, mathematics, and broader STEM to include more diverse students. This is particularly relevant given widespread concerns about students losing interest in science and mathematics during compulsory schooling. It is therefore essential to understand how to support and nurture students who complete compulsory school with strong positive relationships to science and mathematics. Without such efforts, even significant investments in fostering students' interest and engagement in science and mathematics during compulsory school risk being undermined if these subjects during upper secondary education ultimately discourage them from seeing futures within the STEM fields as something for them. This represents a considerable loss of potential. Hence, we call for further longitudinal research addressing diverse groups of students, as it is well established that identities in physics and mathematics intersect with broader social categories such as gender, race/ethnicity, and social class.

ACKNOWLEDGMENTS

The research was funded by the Novo Nordisk Foundation [Grant No. NNF21OC0072064].

DATA AVAILABILITY

The data that support the findings of this article are not publicly available because they contain sensitive personal information.

-
- [1] L. Archer, J. DeWitt, J. Osborne, J. Dillon, B. Wong, and B. Willis, *ASPIRES: Young people's science and career aspirations*, age 10–14, King's College London, London (2013). https://kclpure.kcl.ac.uk/portal/en/publications/aspires-report-young-peoples-science-and-career-aspirations-age-1/?utm_source=chatgpt.com.
 - [2] DEA, *Litteraturstudie: Unges veje til STEM [Literature study: Young people's paths to STEM]*, Available from: <https://www.datocms-assets.com/22590/1589284082-stelitteraturstudie.pdf> (2018) [cited November 18, 2024].
 - [3] P. Anderhag, P.-O. Wickman, K. Bergqvist, B. Jakobson, K. Mikael Hamza, and R. Säljö, Why do secondary school students lose their interest in science? Or does it never emerge? A possible and overlooked explanation, *Sci. Educ.* **100**, 791 (2016).
 - [4] D. Cheung, The key factors affecting students' individual interest in school science lessons, *Int. J. Sci. Educ.* **40**, 1 (2018).
 - [5] S.-i. Kim, Y. Jiang, and J. Song, The effects of interest and utility value on mathematics engagement and achievement, in *Interest in Mathematics and Science Learning*, edited by K. A. Renninger, M. Nieswandt, and S. Hidi (American Educational Research Association, Washington, DC, 2015).
 - [6] L. Steidtmann, T. Kleickmann, and M. Steffensky, Declining interest in science in lower secondary school classes:

- Quasi-experimental and longitudinal evidence on the role of teaching and teaching quality, *J. Res. Sci. Teach.* **60**, 164 (2023).
- [7] A. Calabrese Barton, H. Kang, E. Tan, T. B. O'Neill, J. Bautista-Guerra, and C. Brecklin, Crafting a future in science: Tracing middle school girls' identity work over time and space, *Am. Educ. Res. J.* **50**, 37 (2013).
- [8] C. Hill, C. Corbett, and A. St Rose, *Why So Few? Women in Science, Technology, Engineering, and Mathematics* (American Association of University Women, Washington, DC, 2010).
- [9] UNESCO, Cracking the code: Girls', and women's education in science, technology, engineering, and mathematics (STEM), Available from: <https://unesdoc.unesco.org/ark:/48223/pf0000253479> (2017).
- [10] B. Francis, L. Archer, J. Moote, J. DeWitt, E. MacLeod, and L. Yeomans, The construction of physics as a quintessentially masculine subject: Young people's perceptions of gender issues in access to physics, *Sex Roles* **76**, 156 (2017).
- [11] L. Archer, J. Dewitt, and J. Osborne, Is science for us? Black students' and parents' views of science and science careers, *Sci. Educ.* **99**, 199 (2015).
- [12] E. Seymour and N. M. Hewitt, *Talking about Leaving* (Westview Press, Boulder, CO, 1997), Vol. 34.
- [13] L. Archer, J. Moote, and E. MacLeod, Learning that physics is "not for me": Pedagogic work and the cultivation of habitus among advanced level physics students, *J. Learn. Sci.* **29**, 347 (2020).
- [14] C. Chen, G. Sonnert, and P. M. Sadler, The effect of first high school science teacher's gender and gender matching on students' science identity in college, *Sci. Educ.* **104**, 75 (2020).
- [15] Z. Hazari, G. Sonnert, P. M. Sadler, and M.-C. Shanahan, Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study, *J. Res. Sci. Teach.* **47**, 978 (2010).
- [16] T. A. Alhaddab and S. A. Alnatheer, Future scientists: How women's and minorities' math self-efficacy and science perception affect their STEM major selection, in *Proceedings of the 2015 IEEE Integrated STEM Education Conference, Princeton, NJ* (IEEE, New York, 2015).
- [17] A. Bandura, C. Barbaranelli, G. V. Caprara, and C. Pastorelli, Self-efficacy beliefs as shapers of children's aspirations and career trajectories, *Child Dev.* **72**, 187 (2001).
- [18] A. Y. Kim, G. M. Sinatra, and V. Seyranian, Developing a STEM identity among young women: A social identity perspective, *Rev. Educ. Res.* **88**, 589 (2018).
- [19] L. Archer and H. Mendick, Becoming exceptional: The role of capital in the development and mediation of mathematics identity and degree trajectories, *Educ. Stud. Math.* **118**, 119 (2024).
- [20] L. Black, J. Williams, P. Hernandez-Martinez, P. Davis, M. Pampaka, and G. Wake, Developing a "leading identity": The relationship between students' mathematical identities and their career and higher education aspirations, *Educ. Stud. Math.* **73**, 55 (2010).
- [21] J. M. Kane, Young African American children constructing academic and disciplinary identities in an urban science classroom, *Sci. Educ.* **96**, 457 (2012).
- [22] R. Dou, Z. Hazari, K. Dabney, G. Sonnert, and P. Sadler, Early informal STEM experiences and STEM identity: The importance of talking science, *Sci. Educ.* **103**, 623 (2019).
- [23] Z. Hazari, D. Chari, G. Potvin, and E. Brewaele, The context dependence of physics identity: Examining the role of performance/competence, recognition, interest, and sense of belonging for lower and upper female physics undergraduates, *J. Res. Sci. Teach.* **57**, 1583 (2020).
- [24] I. Drymiotou, C. Constantinou, and L. Avraamidou, Would a career in science suit me? Students' self-views in relation to science and STEM career aspirations, *Int. J. Sci. Educ.* **47**, 1428 (2025).
- [25] C. G. Dixon, E. M. Harris, and H. Ballard, Identities in action: Opportunities and risks of identity work in community and citizen science, in *Science Identities: Theory, Method and Research* (Springer, New York, 2023), pp. 247–269.
- [26] H. B. Carlone, Understanding and contextualizing the field of science identity research, in *Science Identities: Theory, Method and Research* (Springer, New York, 2023), pp. 3–20.
- [27] S. M. James Butterfield and K. B. Marshall, Using qualitative metasynthesis to understand the factors that contribute to science identity development across contexts in secondary and post-secondary students from underrepresented groups, in *Science Identities: Theory, Method and Research* (Springer, New York, 2023), pp. 273–298.
- [28] H. B. Carlone, C. M. Scott, and C. Lowder, Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science, *J. Res. Sci. Teach.* **51**, 836 (2014).
- [29] L. Archer, S. Godec, and J. Moote, "My love for it just wasn't enough to get me through": A longitudinal case study of factors supporting and denying black British working-class young women's science identities and trajectories, in *Science Identities: Theory, Method and Research* (Springer, New York, 2023), pp. 23–45.
- [30] G. M. Quan, C. Turpen, and A. Elby, Analyzing identity trajectories within the physics community, *Phys. Rev. Phys. Educ. Res.* **18**, 020125 (2022).
- [31] H. B. Carlone and A. Johnson, Understanding the science experiences of successful women of color: Science identity as an analytic lens, *J. Res. Sci. Teach.* **44**, 1187 (2007).
- [32] J. Cribbs, Z. Hazari, G. Sonnert, and P. M. Sadler, College students' mathematics-related career intentions and high school mathematics pedagogy through the lens of identity, *Math. Educ. Res. J.* **33**, 541 (2021).
- [33] J. D. Cribbs, Z. Hazari, G. Sonnert, and P. M. Sadler, Establishing an explanatory model for mathematics identity, *Child Dev.* **86**, 1048 (2015).
- [34] H. B. Carlone, The cultural production of science in reform-based physics: Girls' access, participation, and resistance, *J. Res. Sci. Teach.* **41**, 392 (2004).
- [35] H. T. Holmegaard, L. M. Ulriksen, and L. M. Madsen, The process of choosing what to study: A longitudinal study of upper secondary students' identity work when choosing higher education, *Scand. J. Educ. Res.* **58**, 21 (2014).
- [36] J. Bruner, *Acts of Meaning: Four Lectures on Mind and Culture* (Harvard University Press, Cambridge, MA, 1990), Vol. 3.

- [37] T. R. Sarbin, The narrative as a root metaphor for psychology, in *Narrative Psychology: The Storied Nature of Human Conduct* (Praeger, New York, 1986), pp. 1–27.
- [38] J. Bruner, The narrative creation of self, in *The Handbook of Narrative and Psychotherapy: Practice, Theory, and Research*, edited by L. E. Angus and J. McLeod (Sage Publications, Inc., Thousand Oaks, CA, 2004), pp. 3–14.
- [39] T. L. Strayhorn, *College Students' Sense of Belonging: A Key to Educational Success for All Students* (Routledge, New York, 2018).
- [40] K. Tobin and W.-M. Roth, *The Culture of Science Education: Its History in Person* (Brill, Rotterdam, 2007), Vol. 3.
- [41] H. T. Holmegaard, L. M. Madsen, and L. Ulriksen, A journey of negotiation and belonging: Understanding students' transitions to science and engineering in higher education, *Cult. Stud. Sci. Educ.* **9**, 755 (2014).
- [42] D. Holland *et al.*, *Agency and Identity in Cultural Worlds* (Harvard University Press, Cambridge, MA, 1998).
- [43] H. T. Holmegaard, L. M. Madsen, and K. B. Nielsen, "You have to ask the right questions": A spatial analysis of the sense of belonging within higher education computer science, *Eur. J. Eng. Educ.* **48**, 1037 (2023).
- [44] K. C. McLean and M. W. Pratt, Life's little (and big) lessons: Identity statuses and meaning-making in the turning point narratives of emerging adults, *Dev. Psychol.* **42**, 714 (2006).
- [45] D. P. McAdams and P. J. Bowman, Narrating life's turning points: Redemption and contamination, in *Turns in the Road: Narrative Studies of Lives in Transition*, edited by D. P. McAdams, R. Josselson, and A. Lieblich (American Psychological Association, Washington, DC, 2001), pp. 3–34.
- [46] J. H. Laub and R. J. Sampson, Turning points in the life course: Why change matters to the study of crime, *Criminology* **31**, 301 (1993).
- [47] F. Kupferberg, Conclusion: Theorising turning points and decoding narratives, in *Biography and Turning Points in Europe and America* (The Policy Press, Bristol, 2012), pp. 227–260.
- [48] L. Avraamidou, Science identity as a landscape of becoming: Rethinking recognition and emotions through an intersectionality lens, *Cult. Stud. Sci. Educ.* **15**, 323 (2020).
- [49] R. Jenkins, *Social Identity* (Routledge, New York, 2014).
- [50] Ministry of Higher Education and Science, The Danish education system, available from <https://ufm.dk/en/education/the-danish-education-system/upper-secondary-education> (2023) [cited June 20, 2023].
- [51] B. Flyvbjerg, Case study, in *The Sage Handbook of Qualitative Research*, edited by N. K. Denzin and Y. S. Lincoln (SAGE Publications, Thousand Oaks, CA, 2011), 4th ed., pp. 301–316.
- [52] S. Kvale and S. Brinkmann, *Interviews: Learning the Craft of Qualitative Research Interviewing*, 2nd ed. (SAGE Publications, Thousand Oaks, CA, 2009).
- [53] M. Andrews, C. Squire, and M. Tamboukou, *Doing Narrative Research*, 2nd ed. (SAGE Publications, London, 2013).
- [54] V. Braun and V. Clarke, Using thematic analysis in psychology, *Qual. Res. Psychol.* **3**, 77 (2006).
- [55] V. Braun and V. Clarke, Reflecting on reflexive thematic analysis, *Qual. Res. Sport Exercise Health* **11**, 589 (2019).
- [56] R. Jorgensen, P. Gates, and V. Roper, Structural exclusion through school mathematics: Using Bourdieu to understand mathematics as a social practice, *Educ. Stud. Math.* **87**, 221 (2014).
- [57] H. T. Holmegaard and B. F. Johannsen, Science talent and unlimited devotion: An investigation of the dynamics of university students' science identities through the lens of gendered conceptualisations of talent, in *Science Identities: Theory, Method and Research* (Springer, New York, 2023), pp. 113–140.
- [58] E. Gertz, L. M. Madsen, and H. T. Holmegaard, "It's not like i go oh that's really exciting"—A qualitative study of upper secondary school students' identity negotiations in physics, *Int. J. Sci. Math. Educ.* **23**, 713 (2025).
- [59] M. V. Bøe, E. K. Henriksen, and C. Angell, Actual versus implied physics students: How students from traditional physics classrooms related to an innovative approach to quantum physics, *Sci. Educ.* **102**, 649 (2018).
- [60] R. Taconis and U. Kessels, How choosing science depends on students' individual fit to "science culture", *Int. J. Sci. Educ.* **31**, 1115 (2009).
- [61] H. Bartholomew, L. Darragh, F. Ell, and J. Saunders, "I'm a natural and I do it for love!": Exploring students' accounts of studying mathematics, *Int. J. Math. Educ. Sci. Technol.* **42**, 915 (2011).
- [62] B. Wong, Identifying with science: A case study of two 13-year-old "high achieving working class" British Asian girls, *Int. J. Sci. Educ.* **34**, 43 (2012).
- [63] H. Mendick, Mathematical stories: Why do more boys than girls choose to study mathematics at AS-level in England?, in *Masculinity and Education* (Routledge, New York, 2016), pp. 83–99.
- [64] P. Den Brok, J. van Tartwijk, T. Wubbels, and I. Veldman, The differential effect of the teacher–student interpersonal relationship on student outcomes for students with different ethnic backgrounds, *Br. J. Educ. Psychol.* **80**, 199 (2010).
- [65] H. Mendick, *Masculinities in Mathematics* (McGraw-Hill Education, New York, 2006).
- [66] L. Archer, E. Dawson, J. DeWitt, S. Godec, H. King, A. Mau, E. Nomikou, and A. Seakins, Killing curiosity? An analysis of celebrated identity performances among teachers and students in nine London secondary science classrooms, *Sci. Educ.* **101**, 741 (2017).
- [67] H. B. Carlone, Producing good science students: Girls' participation in high school physics, *J. Women Minorities Sci. Eng.* **9**, 17 (2003).
- [68] M. V. Bøe and E. K. Henriksen, Love it or leave it: Norwegian students' motivations and expectations for postcompulsory physics, *Sci. Educ.* **97**, 550 (2013).
- [69] E. Gertz, Hvordan unge kvinder oplever, at køn spiller ind i læring af naturvidenskab og matematik på STX, *MONA* **25**, 7 (2025).
- [70] J. M. Nissen and J. T. Shemwell, Gender, experience, and self-efficacy in introductory physics, *Phys. Rev. Phys. Educ. Res.* **12**, 020105 (2016).

- [71] A. J. Gonsalves, “Physics and the girly girl—There is a contradiction somewhere”: Doctoral students’ positioning around discourses of gender and competence in physics, *Cult. Stud. Sci. Educ.* **9**, 503 (2014).
- [72] L. Archer *et al.*, The “exceptional” physics/engineering girl: A sociological analysis of longitudinal data from girls aged 10–16 to explore gendered patterns of post-16 participation, *Am. Educ. Res. J.* **54**, 88 (2016).
- [73] S. Galano, A. Liccardo, A. L. Amodeo, M. Crispino, O. Tarallo, and I. Testa, Endorsement of gender stereotypes affects high school students’ science identity, *Phys. Rev. Phys. Educ. Res.* **19**, 010120 (2023).
- [74] F. Jaremus, When girls do masculinity like boys do: Establishing gender heteroglossia in school mathematics participation, *Math. Educ. Res. J.* **33**, 713 (2021).
- [75] P. A. Jackson and G. Seiler, Identity work in the college science classroom: The cases of two successful latecomers to science, *Sci. Educ.* **101**, 716 (2017).
- [76] Y. Chevallard and M. Bosch, Didactic transposition in mathematics education, in *Encyclopedia of Mathematics Education*, edited by S. Lerman (Springer International Publishing, Cham, 2020), pp. 214–218.
- [77] B. Wong and Y. T. Chiu, *The Ideal Student: Deconstructing Expectations in Higher Education* (McGraw-Hill Education, New York, 2021).
- [78] K. D. Tanner, Structure matters: Twenty-one teaching strategies to promote student engagement and cultivate classroom equity, *CBE Life Sci. Educ.* **12**, 322 (2013).
- [79] L. Archer *et al.*, Applying the principles of culturally sustaining pedagogy to a model for justice-oriented school science pedagogy in England: The science capital teaching approach, *Lond. Rev. Educ.* **22**, 1 (2024).
- [80] M. V. Bøe, Staying recognised as clever: High-achieving physics students’ identity performances, *Phys. Educ.* **58**, 035012 (2023).
- [81] M. Good, A. Maries, and C. Singh, Additional unexpected benefits of rewarding students for effective problem solving strategies: Supporting gender equity in physics, *Phys. Educ.* **57**, 055005 (2022).