Using expectancy-value theory to understand the teaching motivations of women physics lecturers

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Being lectured by a woman physicist can benefit students' performance, motivation, and engagement with physics. However, due to the severe underrepresentation of women physics faculty, these instances may be scarce. Through semistructured interviews with seven women physics lecturers, we used expectancy-value theory to understand the situative nature of gender regarding motivation to lecture. We sought to understand their choices and decisions when selecting their teaching roles, and if lecturing, what draws them toward certain courses. Our study was a staff-student partnership project carried out in a physics department at a UK university. We identified themes of confidence, enjoyment, the importance of lecturing, and the associated workload. The academic women could not relate to the "showperson" persona that they felt their men colleagues displayed. They navigated low levels of confidence by adopting a painstaking approach to lecture preparation, suggesting an inherent, higher workload associated with lecturing, compared with other forms of teaching. However, the women highly valued lecturing, enjoying the excitement and interactions with students, and were drawn toward developing students' knowledge and skills. Being familiar with the content allowed them to feel confident in lecturing. We discuss these findings and recommend areas of support that physics departments should endeavor to offer.

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I. INTRODUCTION

Women continue to be underrepresented at all levels in physics higher education, both in the United Kingdom and globally. Recent figures for the United Kingdom show that women comprise 24% of undergraduate students, 26% of postgraduate students, and only 19% of academic staff in physics [1,2]. Although slowly increasing on average [3], representation continues to be an issue in individual institutions; in the physics department where this study took place, only 13% of the academic staff were women.

At the faculty level, physics is perceived as masculine and that masculine qualities are needed to succeed [4], which can disadvantage women [5]. Women in physics academia experience imposter syndrome [6], lower maths and science self-efficacy than men [7], and an incompatibility of an academic career with core personal values, such as work-family balance [8]. Indeed, higher education generally is viewed as masculine and competitive, involving power structures and microaggressions, leading to women being underrepresented in senior positions [9,10]. Women faculty members are more likely to undertake service or pastoral roles [11] and report perceived injustice which is associated with reduced job satisfaction, increased scholarly isolation, and stress [12]. One meta-analysis found that women were more likely to experience burnout, particularly emotional exhaustion [13].

Although academic staff enjoy autonomy in how they allocate their time between teaching, research, and professional service [14,15], this low proportion of academic staff in physics who are women means they are underrepresented in teaching roles, which has potential implications for undergraduate physics students. Studies have shown that a woman instructor benefits students' academic performance, motivation, and retention in a subject [16–18]. Women instructors benefit students' engagement and interest in science, technology, engineering, and maths (STEM) [19] and increase their self-efficacy, positive attitudes, and identification with STEM [20]. These benefits are even greater for women students, as students have better connections with professors whom they share socially constructed identities with and can relate to, which can facilitate science identity production [21], a known factor for pursuing a career in physics [22]. However, the quality of a role model is more important than the mere presence of a role model, and this can influence students' ability to form a sense of belonging to physics [23].

One way to tackle this underrepresentation is by focusing on existing academic women in physics and investigating

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their teaching motivations. We focus on lecturing as part of their teaching duties, as this provides the most widespread student contact time and, anecdotally, is often seen as a prestigious position among students at our institution. Lecturing is characterized by large cohorts and traditional, teacher-directed instruction and is the most common teaching approach used in higher education, with the vast majority of content delivered for science and maths in the form of lecturing [24,25]. Lecturing is perceived to be highly beneficial for students, as students are taught by experts in the field and lecturers offer a unique perspective that cannot be found in textbooks [26].

However, the low numbers of women physics faculty further means that theoretically, an undergraduate student could complete their degree without being lectured by a single woman physicist. Indeed, this issue was raised by students at our institution and so motivated the use of a staff-student partnership. Our research was guided by these student-facing issues in order for it to have a local impact. This study therefore aimed to understand the decisions academic women physicists make when choosing whether to lecture as part of their teaching duties, and if so, what motivates them to choose specific lecture courses. To do this, we used semistructured interviews through the lens of expectancy-value theory. We used the interpretivist paradigm, using qualitative methods to describe in detail the academic women's lived experiences around teaching and lecturing [27].

Our findings add to the existing literature twofold. First, we extended the research on the underrepresentation of women faculty in physics. Second, we used qualitative methods and applied expectancy-value theory to a unique setting that is underresearched: faculty teaching motivation. Many studies have focused on gender differences in research practices in academia [28], but none have focused on teaching motivations in physics—does this operate in a similarly gendered way? Our study provides a unique perspective on the academic women and how they prioritize their commitments, which will allow departments to understand better how to support them in their teaching duties, their careers, and improve job satisfaction.

These findings may then work toward increasing the visibility of role models in undergraduate physics degree programs. Furthermore, an increase in the representation of women faculty has benefits for the staff members themselves. Experiencing a sense of community, support, and control, is linked to women faculty's job satisfaction [29]. A professor participant in [30] reported that there is a nicer atmosphere, less aggression, and less competition with an increased number of women. The authors in [31] suggest that increased visibility would also help to reduce the persistent stereotyping that women face, such as the gender bias in student evaluations of lecturers, where women physics professors were rated less knowledgeable and less skillful than men professors. Finally, due to the low representation, academic women often feel the need to take on specific teaching duties as a "token" gesture [30]. By understanding the needs and experiences of women by focusing on their teaching decisions, we avoid the issues of increased visibility in a purely tokenistic way. In the sections that follow we describe the existing literature on the teaching motivations of academic staff, our theoretical framework, and finally our research questions.

A. Teaching motivation in higher education

Teaching beliefs and practices, rather than motivation *per se*, dominate the research on academic lecturers [32–34], despite motivation affecting an individual's performance, effort, and persistence [35]. Furthermore, motivation studies have mostly focused on self-efficacy and self-concept beliefs, usually in the context of students or school teachers, rather than academic lecturers. Self-efficacy is a central construct of social cognitive theory [36] and is situational, i.e., it is an individual's belief that they will succeed at a given task [37]. Self-concept is how an individual perceives themselves and is domain-specific, for example, academic self-concept [38]. The relatively few studies that have investigated lecturers' motivation have focussed on self-efficacy in terms of the teaching-research dichotomy, rather than purely teaching self-efficacy [39]. Despite research having a higher status than teaching in academia [10], and lecturers being more likely to identify as scientists or researchers than educators [40], lecturers often have higher teaching self-efficacy than research self-efficacy [39,41]. Both research and teaching self-efficacy are related to job satisfaction and teaching motivation [41,42]. Mastery experiences, social persuasion, student and peer feedback, mentoring, and professional development are some of the main sources of teaching self-efficacy [39,42–44]. Lecturers' self-efficacy can also be affected by the responsiveness of their students and how engaged they are, with low student engagement linked to low self-efficacy for lecturers [42,45]. Reciprocally, lecturers' self-efficacy impacts students as well—students learn more, perceive they have learned more, and have better classroom engagement with lecturers with high teaching self-efficacy [42].

In terms of gender, while there are mixed findings for how women's teaching self-efficacy compares to men's; studies have shown that women lecturers have lower research self-efficacy than men [42,46]. Women are more likely to have higher teaching workloads, mentor more students, and spend more time on teaching preparation (such as engaging with educational literature or having discussions with colleagues), compared with men who spend more time on research [47,48]. In a comparative study of men and women in STEM careers, men were found to acquire their self-efficacy through mastery experiences, while women acquire theirs through social persuasion and vicarious experiences [7,49].

In terms of general teaching motivation, a large-scale survey of over 5000 academics at 19 Australian universities

found that a passion for the discipline, being able to do intellectually stimulating work, and contribute to new knowledge were the factors drawing academics to their career [50]. The pleasure of teaching and developing students' understanding were the most satisfying aspects of their work [50]. Recently, studies have adopted theories of motivation other than self-efficacy, such as self-determination theory, achievement-goal theory, or the role of emotions and task value in teaching [14,15,51,52]. These studies have also focussed on teaching versus research, however. Regarding achievement-goal theory, academics' teaching goals displayed more variability than their research goals [53]. With regard to emotions, teaching has been shown to be associated with stronger positive emotions (such as pride, enjoyment, and relief) compared with research or service [54].

The authors in [52] suggest some possible reasons for the lack of research on lecturers' motivation that does not focus on teaching beliefs or self-efficacy, including "false assumptions" (researchers assume lecturers are already highly motivated) and "methodological challenges" (low sample sizes and social intimidation from interviewing colleagues) [53]. There is also a reliance on quantitative methodologies, with authors highlighting the need for more in-depth, qualitative studies [39,42,52]. Therefore, it is important to understand lecturers' motivations in detail, particularly for academics who are underrepresented such as women or faculty of color [51].

B. Theoretical framework: Expectancy-value theory

Our study draws on the expectancy-value theory of motivation which combines expectancies for success and subjective task value to describe achievement-related choices. It describes how an individual's beliefs move them toward or away from a task. An individual will be motivated to pursue a task if they both believe that they will do well and attribute value to it [55–57]. These expectancies and values are influenced by interpretations of past experiences and perceptions of others' expectations [56,57].

Expectancies for success are self-beliefs about how well an individual will perform in tasks and are related to the task-specific concept of self-efficacy [56,57]. Expectancies for success, ability beliefs (self-concept), and task-difficulty all play a role in expectancy-value theory, and despite being highly related concepts, are empirically distinguishable [56,57]. Ability beliefs and expectancies for success differ in "time"—ability beliefs refer to the present moment, whereas expectancies refer to a future task.

The value component of expectancy-value theory comprises four areas: intrinsic value, utility value, attainment value, and cost [56–58]. Intrinsic value refers to the enjoyment experienced while carrying out the task, analogous to intrinsic motivation or interest [59]. Utility value refers to whether the task is useful for meeting future goals, analogous to extrinsic motivation [59]. Attainment value refers to the importance of doing well in the task and whether it aligns with the individual's identity. Finally, cost refers to the negative aspects of engaging with the task, such as the emotional impact, time or effort, or sacrificing of other activities [56,57].

Expectancy-value theory is a prominent theory of motivation and was originally developed to understand gender differences in maths and science enrolment at school and university [58]. Since then, the framework has enjoyed much empirical support and application, mostly to students' learning outcomes and experiences [60,61], with students' academic achievement predicted more strongly by their expectancies, and their course and career choices more strongly predicted by subjective task values [60].

Expectancy-value beliefs are also related to students' achievement, persistence, and retention in STEM [62–64]. In terms of gender, the authors in Ref. [62] state: "Girls tend to have a lower expectation of success and perceive a higher cost associated with studying science and mathematics." Women are underrepresented in high maths or high science motivational belief profiles, and these profiles are more likely to persist in STEM [64]. Motivational beliefs also predict STEM careers more than actual ability, family education, and income and can explain women's higher uptake of life sciences over physical sciences—women value working with people and have altruistic values [65]. In terms of physics, a study of upper secondary and first-year university Norwegian physics students found three distinct expectancy-value profiles, with students more likely to pursue physics through interest and enjoyment, although women were underrepresented in the purely intrinsic value profile [66].

Expectancy-value theory is a valuable framework for exploring and explaining prominent issues in science and maths education, by recognizing the many factors that go into decision making and how these are shaped by social influences and past experiences. Despite this, the expectancy-value theory has not been utilized in understanding academics' motivations more generally, let alone women who have persisted in a STEM career. It has been applied to understanding the motivations of schoolteachers [35] and more specifically, why teachers might exchange information and co-construct knowledge with each other [67]. Ability beliefs and intrinsic value were the main motivators for becoming a schoolteacher, including a desire to work with young people and make a social difference, and to be fulfilled intellectually [35]. However, in terms of cost, teaching is a highly demanding career, requiring expertise [35]. Indeed, the authors in Ref. [15] state, "We were surprised to learn that an expectancy-value lens has not yet been drawn upon in studying academics' motivations, despite its proven fruitfulness in our own research concerning teachers." Since then, the expectancy-value theory has been applied to quite specific contexts in higher education, such as service learning [68] and mentor teachers [69].

We specifically focus on *situated* expectancy-value theory, which emphasizes the situative or contextual factors that influence a person's expectancies and values, such as culture, gender, ethnicity, and environment [70]. Researchers have used quantitative surveys of expectancy-value theory to investigate if expectancies and values predict specific outcomes, such as career choice. Researchers instead need to look within situated expectancy-value theory to explore the developmental processes that shape expectancies and values, ideally using qualitative methods [70,71]—how exactly do people come to have the expectancies and values that they do? We, therefore, apply situated expectancy-value theory to investigate the experiences of academic women in a physics department.

C. Research questions

In order to explore the women physics lecturers' motivations using the framework of expectancy-value theory, our research questions were as follows:

- What allows the academic women to feel like they will succeed at lecturing or lecturing particular courses?
- What do the academic women in the department of physics value in lecturing or lecturing particular courses?

II. METHODOLOGY

A. General context

The study was conducted at a research-intensive, high-tariff university in the United Kingdom. At the time of the study, the physics department had approximately 120 academic staff, of which 14 were women. Academic staff includes lecturers, senior lecturers, readers, and professors. They are contracted to fill approximately 600 teaching hours each academic year with either undergraduate or postgraduate teaching. This includes administrative roles, pastoral roles, project supervision, academic tutorials, laboratory and computing teaching, and lecturing. Lecturing is a significant role in terms of teaching hours and visibility. Each lecture is around 50 min in duration. A typical lecture course comprises around 10–25 lectures, lasting for one term. At any one time, students may be attending 3–5 different lecture courses, alongside tutorials, projects, and lab work.

The physics degree programs offered at the university are 3 or 4 years in duration, and most of the courses in the first and second years are compulsory ('core') with approximately 250 students per cohort. The third and fourth years of the degrees comprise optional modules and are much smaller cohorts, typically around 50 students. As is common in physics, the majority of content for core and optional courses is delivered via traditional, teacher-directed lectures.

If choosing to lecture, academic staff then bid on which courses they would like to lecture, by ranking their chosen courses in order of preference. A committee consisting of academic and administrative staff members in the department meets regularly to discuss these preferences and decide on new lecturer allocations. Lecture courses are reallocated every 4–5 years. Some of the members of this committee were also interviewed to provide context for this study regarding these allocations, however, these findings are outside the scope of this paper. Our study obtained full ethical approval from the university.

B. Research method

A qualitative approach to data collection was adopted as it allows for a deeper exploration of the issue and of each lecturer's personal experiences [72]. All of the academic women and all relevant committee members in the department were invited to be interviewed via email, and a reminder email was sent out 2 weeks later to increase the participation rate. Seven academic women and six committee members accepted our invitation to be interviewed. The academic women were from various research groups and had varying levels of experience in lecturing and seniority in the department.

Our study was a staff-student partnership, involving two undergraduate students (who had just finished the third year of their degree), one postgraduate research student, and two staff members. One undergraduate student and either the postgraduate research student or a staff member conducted the interviews. Having an undergraduate student involved in carrying out the interviews breaks down the social intimidation staff may feel from interviewing other members of staff [52], particularly about their levels of teaching motivation and what influences this.

The interviews were in a semistructured form, whereby we asked a set of open-ended questions prepared in advance, and followed up for further explanation as points were raised (see the Appendix for a full list of questions). Semistructured interviews enable better comparison between interviews while still allowing for further elaboration on new and important points. We began each interview with questions asking the academic women what courses they had lectured and for how long, for context. Further questions for the academic women included "What motivates you to choose lecturing over other teaching roles?" and "What motivates you to choose a particular lecture course?" These were followed up with appropriate prompts, such as questions about career progression, class size, or questions seeking clarification (e.g., "What do you mean by feeling anxious about lecture course allocations?"). Each interview lasted between 30 and 60 min and all members of the research team took turns in conducting the interviews. The interviews were carried out either in person or remotely, and all interviews were carried out in the summer of 2022. Each interview was audio recorded. The two undergraduate student partners were trained in qualitative research methods prior to the start of the interviews by the more experienced members of the research team.

C. Data analysis

Each interview was transcribed using Otter.ai and pseudonymized to prevent identification. Other identifying

information, including references to research groups or particular courses, were also redacted. We used a blend of deductive and inductive analysis, with an emphasis on the latter [73].

The main concepts from the expectancy-value framework (expectancies, intrinsic value, attainment value, utility value, and cost) were used deductively—as a guide to interpret, classify, and sort our themes. As a result, the academic women were not explicitly asked about whether they believed they would be successful at lecturing, or whether they enjoyed lecturing, for example. Questions were open ended to allow space for what the academic women felt important to discuss and to allow detailed narratives about their choices and decisions to appear. We followed Braun and Clarke's six-step framework for reflexive thematic analysis, as this is a powerful yet flexible method to analyze qualitative data [74,75]. We first familiarized ourselves with the transcripts by reading them and collectively identified an individual transcript that discussed a range of topics. This was read carefully by two members of the research team to generate noteworthy patterns and codes. We paid particular attention to comments that we could start to interpret as expectancies or values. The initial codes were then applied to the remaining transcripts and what followed was an iterative process of refinement, application, and discussion. Once all members of the research team agreed, we used these codes to generate *themes*—shared meanings given to the patterns constructed from the data, informed by the expectancy-value framework. As an example, the academic women collectively mentioned various aspects of lecturing they liked, such as the excitement of delivering a lecture or developing the content for the course. We noticed observations of these across the entire group and decided to understand the meaning behind these responses as a rich, multifaceted theme of *enjoyment* in lecturing, i.e., the intrinsic value.

III. RESULTS

The expectancy-value theoretical framework was used as a guide to interpret the responses. We found their expectations for success arose in discussions about what makes them feel confident (or not) and beliefs about their own abilities and others'. When considering what they valued in lecturing, the academic women discussed both enjoyment and the importance of lecturing but also mentioned the workload associated with lecturing. For the rest of this section, we describe in detail how our results address each of the research questions.

A. Expectancy

This section addresses the first research question: What allows academic women to feel like they will succeed at lecturing and lecturing specific courses? The main theme identified in the academic women's responses was confidence—they discussed various factors that did or did not make them feel confident in lecturing. Using the expectancy value framework, we interpreted these discussions as their expectancies for success, including perceived task difficulty. We also interpreted some of their more reflective statements about themselves and their self-confidence levels as ability beliefs, discussed at the end of this subsection.

1. Confidence

Confidence was a significant theme that appeared repeatedly throughout the interviews. The main factors that impacted the women's confidence in lecturing were their familiarity with the material, either in terms of their research expertise or in terms of previous experiences of teaching the course or learning it as a student, how they prepared for and delivered the lectures, and the perceived challenges associated with teaching specific courses. Their discussions centered on lecturing specific courses rather than lecturing generally.

One of the main factors that nearly all of the academic women mentioned would make them feel confident in delivering a lecture course was being familiar with the material. Anna, Chloe, and Catherine mentioned that feeling "comfortable" with the course topic was important and this familiarity naturally arose from lecturing a course within their research specialism. Alice mentioned how choosing courses is a source of anxiety as she was worried about teaching courses she felt she did not have full expertise in:

> I had it in my mind that I can only teach what I know really well and what I feel confident teaching. There are certain courses I wouldn't touch because of confidence and time … I was really anxious for a topic that I knew a lot about, and that was the [research area] side of things, because that's what I do and that's my area. So, I felt relatively confident teaching it.

Chloe also stated that her area of research used a specific area of physics and she used this as a marker of being qualified to teach these courses as did many of the other academic women. However, Anna identified that she felt she could lecture a course that was not her specialism, as long as it was an area she knew about, as she said, "I think I need to have the best expertise on that topic to be able to teach it. It doesn't need to be necessarily related to my research, but I need to feel comfortable in it." Whether the particular course was related to their specialism or not, the women took a lot of confidence from having expertise and used this to judge whether they would be able to do a job good delivering that course.

Another way the academic women felt familiar with the material was through their prior experiences. We further

identified this occurring in two main ways. The first involved reflections on their experiences as undergraduates. For many of the women, simply having taken the course themselves was a source of confidence in teaching it. Alice not only needed to have studied that course as a student but also performed well in it to be able to lecture it well:

> I remember it was the paper I did best on, so I thought this would be a lovely topic to teach. And I felt, because I've done well as an undergraduate, this sort of showed that I was okay at it.

Alice associated her performance with her ability to deliver lectures in this course, suggesting these mastery experiences were also a source of self-efficacy for her.

The second way was through hearing the course being taught by someone else. The academic women relied on the explanations they had heard to shape and guide how they would explain the same concepts to their own students. They would have the "lecturer's voice in the back of [their] mind" and would replicate "how they explained some of the concepts." The academic women relied heavily on these different types of prior experiences for building confidence and therefore as sources of expectancies for success.

Several academic women described how the approach they took to lecturing, in terms of preparation and delivery, allowed them to feel confident. They "spent a lot of time preparing lectures very carefully," which involved planning exactly what was going to be covered in the lectures, writing detailed notes to follow in the lectures, and spending many hours on the preparation itself. Ellie stated,

> I wrote my own notes [with] what I'm going to cover in the lecture, so I know exactly what I'm going to do in the lecture. I write by hand and I have in blue what I'm going to do on the board, in green the things I mentioned earlier, and so forth… Typically, I spend at least 10 hours on a one-hour lecture.

Furthermore, Alice was "shocked" when she received "a thin pile of scribbled notes and prompts" from the previous lecturer for a particular course and spent a long time making "extensive" notes and handouts for the students. She had "exactly what she was going to say written out." This thorough and meticulous approach to lecturing left nothing to chance and allowed the women to believe that they would succeed at lecturing and was often used as an example of why they thought they were good lecturers when considering student evaluations.

Task difficulty: Discussions around the *perceived difficulty of the task* arose when considering which specific lecture courses to teach. Lecturing core courses was seen as a comparatively more difficult task than optional modules because it meant lecturing the entire cohort. Some women therefore expressed a preference for teaching an optional course as they believed the fact students had chosen it contributed to them being more focused and engaged during the lecture. Ellie referred to this as "crowd management" and said that students who are interested and keen "make your life so much easier". Alice summarised these experiences as:

> I liked the fact that the students had chosen [optional course] as they had willingly picked it—they were there out of choice and so I had an audience that was interested. One of the worries I had when I switched to [a core course] was that a lot of the audience were not thrilled to be there. They didn't necessarily like the topic and I had a full range of abilities to deal with, so it was harder.

This dichotomy between optional courses and engaged students versus core courses and disengaged students created feelings of anxiety for Alice when choosing which courses to teach, and affected the perceived difficulty of the task. She and other academic women believed teaching a core course would be "hard" for these reasons, and therefore would feel like they would not be able to do a good job.

The academic women also drew upon the experiences of others lecturing core courses. Sarah described how she has put off core teaching when she observed a colleague lecturing and there was "a lot of messing about" from students and "they weren't engaged". She decided that she "didn't want to be in that position… because of the nature of the interaction between lecturers and students that [she had] observed", suggesting low self-confidence in behavior management. Vicarious experiences were also a potential source of core teaching self-efficacy for Sarah; the experiences she observed transferred to her own self-beliefs, and she too felt she would struggle to engage the cohort.

Overall, for the academic women, feeling confident arose from having expertise in the topic, having positive prior experiences to draw on when lecturing, and taking a diligent approach to the planning and delivery of lectures. The women did not state that they needed all of these to feel confident but remarked how any one of them would make them strongly consider lecturing a particular course. The women were less likely to feel confident teaching a core course due to the issues around behavior management and the increased likelihood of student disengagement.

Ability beliefs: Most of the academic women also made explicit, reflective statements about their own lecturing abilities, i.e., their *ability beliefs*. This was mostly in reference to their teaching style and delivery of lectures or from student evaluations. For their teaching style and delivery, the academic women felt they were approachable and clear and that students could understand the material if they persevered with their lectures. For the student evaluations, however, the women had accepted that they would not receive the highest evaluations from students. Chloe

explicitly mentioned how this could be related to her gender, as she "[knew] that women get poorer marks on teaching evaluations as a rule," and for exactly this reason, she would "not be a top lecturer."

Despite being aware of these biases against academic women, the women had negative images of themselves that were often fed from the student evaluations. Catherine believed she was "alright at lecturing, but not outstanding," while Chloe thought she "can probably [communicate] better." As well as influencing their self-confidence, the student evaluation and its biases may lead to feelings of discouragement or frustration.

In addition to statements about themselves, the women positioned themselves and their own abilities with respect to their colleagues' abilities in lecturing. References to other lecturers referred to how highly rated they were by students, and how other lecturers' delivery was quite different from their own. Many of the academic women mentioned a "showperson persona" that the students responded well to but that they could not identify with. According to the academic women, students liked lecturers who "do a bit of a song and dance and who are quite ebullient" and "have personality." However, the academic women felt they were "not like that at all" and "didn't enjoy performing." For some of the women, this persona was explicitly mentioned as being performed by their men colleagues and demonstrates masculine traits such as assertiveness. Alice said,

> When I was a young lecturer…there'd be a professor striding around, waving his arms, full of energy and quite loud, and people used to admire this. You got the feeling that everyone admired these big presences, and I felt very different to that. I always feel that I don't fit in with that kind of booming showman—basically, I'm not a showman.

while Sarah remarked, "They're confident, they're engaging, they're charismatic, they enjoy being a showman. All the examples I can think of are showmen." Chloe, however, felt that with experience she could maybe identify with these characteristics, as she said "I think maybe it's partly because I don't have as much experience. I think the more experience I get, the better I will get at those things." Two academic women explicitly mentioned imposter syndrome and stated that they "always feel that there's another staff member who could be better at [lecturing] than [them]." Comparisons to others' abilities affected their own self-confidence and created feelings of doubt for the academic women.

Overall, the statements we interpreted as the academic women's ability beliefs painted a relatively negative picture of how they viewed themselves and their abilities. When reflecting on their own abilities, they expected only small amounts of success, particularly in comparison to other (men) colleagues, by being diligent, clear, and thorough.

B. Value

This section addresses the second research question: What do the academic women value in lecturing and lecturing specific courses? The main themes identified were enjoyment, the importance of lecturing, and the workload, which we interpret as intrinsic value, attainment value, and cost, respectively, using the expectancy-value framework. The academic women highly valued lecturing due to personal enjoyment and the ability to develop students' knowledge and skills. However, the women also noted costs not found in other forms of teaching such as the associated workload and fitting in lecture preparation around other personal responsibilities. Our findings did not reveal any utility value in lecturing (such as a requirement for promotion) for the academic women. However, this could still be a factor for academic women in other career stages or contexts.

1. Enjoyment

Enjoyment was an important, intrinsic value for our academic women—they greatly enjoyed lecturing and found it to be a very fulfilling and rewarding form of teaching. Their enjoyment arose in three main ways: excitement in delivering the lectures, creative freedom in designing a lecture course, and the interactions with students.

In terms of excitement, Ellie, Catherine, Alice, and Sophie all described the "high," "buzz," and "adrenaline rush" that they get from delivering a lecture and how this set lecturing apart from other forms of teaching; as Sophie stated, "Lecturing is more exciting, for sure, you get a buzz from it." This buzz came from lecturing being "a bit like giving a performance."

However, the women had to work at creating this excitement, as Catherine said, "I sometimes think it's hard when you go into a large lecture theatre, but if you stand in front of 200 people and it works, it gives you a high, it's really fantastic," and Alice, "Once I've got past the nervousness, I actually love it when I'm standing there giving lectures, I really enjoy it." This could suggest that the inability to identify as a "showman" manifests itself not only through low lecturing self-concept but also through the idea that for the academic women, lecturing (and performing) does not come naturally to them and is a source of nervousness. This is despite lecturing being ultimately exciting and full of positive emotions—these experiences did not influence how they saw themselves and their abilities, suggesting expectancies carry more motivational weight than intrinsic value alone.

When lecturers take on a lecture course, there is scope for adjusting the content according to their interests and what they deem important for the students to learn. The women greatly enjoyed this creativity and freedom

involved in being able to shape a lecture course. When talking about how she structured the content for a lecture course, Sophie stated, "You've got complete freedom in actually designing what you're doing, which is a big plus for me." This creativity and pedagogical freedom allowed the academic women to feel like they had ownership of the course and material, which increased the value of lecturing, as Catherine said,

> You don't just want to teach a course and not make it your own. That's part of the fun—there's the core curriculum and you have to teach certain things, but you can approach them in a different way. It's more interesting when you've got some stake in the thing.

This enjoyment was further enhanced when lecturing within their specialism, as Sarah said "So this kind of creative aspect… it's very nice to sort of have the opportunity to explain [research area]." Sarah felt the creative aspect tied in nicely with her own research interests, adding to the value of lecturing for her. This intrinsic value of ownership and agency was also evident in other teaching roles, as Alice stated, "I became [other teaching role], which I enjoyed because then I could do it the way I wanted to do it."

The final way in which enjoyment was realized was through interaction with students. When compared with other teaching roles, Sophie simply stated, "I would pick lecturing because I like interacting face-to-face with the students." The academic women both relied on and valued the real-time feedback they got from the students in the lecture, as Sarah said,

> I really like it if when you're actually giving the lecture, you feel that the class is engaged and that you're getting the point across. If that's then followed up by questions at the end… to actually have evidence that you stimulated the interest of the class, through the stuff that you put in front of them, that's very valuable and rewarding.

This feedback allowed them to internally evaluate their performance and motivated them further in lecturing. Ellie mentioned the reciprocal relationship between delivering the lecture to the students and receiving feedback from the students during the lecture, in the form of a smile or interaction, which she described as "contributing to [her] motivation." The value of student interaction was reinforced for her during the COVID-19 pandemic and the associated online learning periods: "I could really see it when we went into lockdown… I really missed [the interaction] in lockdown."

Overall, the academic women highly enjoyed lecturing and spoke fondly of the buzz that lecture delivery gave them and discussed that it was a big source of motivation to do well. Creative freedom and the opportunity to interact with students were also highly desirable aspects and important considerations in their teaching choices.

2. Importance

All of the academic women spoke about how important lecturing was, in terms of what they believed the goals of lecturing were. We interpreted this as the attainment value of lecturing—they believed it was important to lecture, which motivated them to take on this responsibility. The academic women expressed a range of beliefs about the goals of lecturing, ranging from transmissive, such as the "transfer of knowledge" (Anna) and "passing on something" (Ellie), to more constructivist, such as students becoming "independent physicists" (Catherine) and "using the skills for life afterwards" (Anna). Whatever the goal, the academic women wanted to play this role in the student's education, largely by contributing to the development of these skills and knowledge. The academic women were very aware of the impact they could have on students' education.

Most of the academic women were also motivated by the chance to inspire the students and stimulate their intrinsic value in physics, through "interest," "enjoyment," and "enthusiasm." Sophie described how important it is for her lectures to generate interest and enthusiasm in students: "I hope that students really enjoy the lectures. For me, generating enthusiasm and enjoyment is actually the most important thing." She mentioned that students would be less likely to enjoy the lectures if they did not understand the material, suggesting she feels motivated to deliver good-quality lectures.

Lecturing familiar courses held additional attainment value for the academic women, as they could provide cutting-edge knowledge and expertise, enhancing the students' experiences. Anna, and others, were able to recognize their expertise and the impact it would bring, over other sources. Anna stated,

> I think you do need to bring something to the students that they wouldn't just get by looking at a textbook, otherwise, they can just get a textbook and follow along… I think it's important because if you don't give your own perspective, then they don't gain anything from you, and then you might as well just get the course from anyone else.

Being able to be the one to provide this unique experience motivated many of the academic women to lecture, showing they were proud of their expertise.

Some of the academic women referred to the importance of the gender representation of lecturers and felt that lecturing provided an opportunity to be a role model for the undergraduate women. Chloe explained how the gender representation was a big motivation for her choosing a core lecture course:

> Just looking at all of the core courses and not seeing any women there except for the fourth year, it's just shocking. So, I thought it would be really valuable for the students to have a female lecturer—that was another big motivation for me to bid for that course.

She further hoped that "being visible" among the teaching staff would "improve things for the future for future students," suggesting she was aware of and motivated by the positive impact she could have as a woman lecturer. Furthermore, Sophie referred to the impact academic women can have on their colleagues, as she saw her "fantastic female academics" as "role models." This suggests that the academic women understood the benefits they can bring to the academic community, not just for students but for staff as well.

Overall, lecturing had high attainment value for the academic women—they were motivated by the opportunity to deliver excellent teaching that would inspire and develop the students' skills and knowledge. Some of the women recognized how their gender or expertise would enhance this further.

3. Workload

The perceived cost of lecturing was its associated workload, which was further divided into the time or effort required and fitting it in around personal commitments. All of the academic women felt that lecturing was very time intensive, describing the workload as "overwhelming," "stressful," and that they were "stretched so thin." This workload was associated with planning and delivering the lectures ("You spend a huge amount of time preparing"—Ellie). Despite this, they still retained their enjoyment for lecturing, as Ellie and Sarah respectively said, "I do enjoy lecturing, but it requires a lot of work," and "I would say teaching is fantastic if you have enough time to do it properly."

This lecturing workload was increased for courses outside their expertise or one they hadn't taught for a long time. With an already intensive workload, the women preferred a course that wouldn't require any extra work on top of the preparation already involved, as Catherine stated "It's such a long time ago that if I had to teach [course], I would have to learn it all from scratch. So, I'm not going to volunteer for that, it's part of the workload." Alice felt that she couldn't indulge in choosing an unfamiliar course because she was "juggling so many things," as she said,

> One of the reasons that I picked these topics to teach was because there wasn't enough time to prepare a course that I didn't know. I would never have dreamt of picking a topic I wasn't familiar with because there's not the luxury to immerse myself in it and learn something new.

This suggests that the academic women felt they had very little initial content knowledge in courses they were unfamiliar with, despite potentially having studied these as students themselves or taught them earlier in their career. These experiences did not seem to translate into allowing them to feel like they could teach the course with only a small time investment.

The workload for lecturing was considered to be in competition not only with research commitments but also with their personal lives, especially for those with children, which made the work-life balance harder. Ellie described feelings of guilt in managing being a mother and working, and said, "I can't be a full-time researcher and full-time teacher and a full-time mother; I'm not superhuman." Family commitments were a factor when considering which teaching roles to take on. Sophie mentioned that childcare responsibilities meant she preferred a role she could do remotely rather than one requiring her to be on campus. These factors also played a role when considering which lecture course to choose, and some academic women felt inclined to put these family commitments first ("My decision was I needed something that wasn't going to be too time consuming, because at the time I was dealing with [family commitment], which needed a lot of my time"—Alice) but recognized that this would affect their research or teaching.

Overall, lecturing carried a large workload that at times was in competition with personal responsibilities. This workload arose from the planning and preparation, which meant that lecturing an unfamiliar course was not a feasible option, due to the extra work required.

IV. DISCUSSION

The expectancy-value framework provided a valuable and useful lens to interpret and understand the academic women's lecturing motivations and decisions. We identified their comments around what allows them to feel confident (or not) as their expectancies for success. Courses within their specialism, or taking a meticulous approach to planning, for example, allowed them to feel like they would do well at lecturing. Unfamiliar material or courses with perceived behavior management issues reduced this confidence. We identified their enjoyment (through the excitement or the interactions with students) as the intrinsic value of lecturing and the importance of lecturing (and wanting to be part of delivering the teaching) as the attainment value. Lecturing had a large associated workload, which we interpreted as the cost. We did not identify any utility value in lecturing for the academic women. This was not surprising, as promotions are usually based on research performance, and the academic women were at stable points in their careers, unlike students [70].

Lecturing (compared with other teaching roles) had an intrinsic workload for the academic women, in terms of thorough planning, preparation, and delivery. Academic

women spend many hours doing service work, often to the detriment of their research [12]. This extra work is also reflected in our findings around lecturing as our academic women were spending 10 h planning a single lecture. This was in order to feel confident, even if it was a course they had taught or seen before. We can identify this as a type of outcome expectancy—beliefs about what you need to do to succeed at the task, compared with efficacy expectancies—beliefs about whether you can succeed [56,57].

This approach to planning lectures can be seen as an adoption of a feminine way of lecturing. Physics as a discipline is characterized by typically masculine practices, such as assertiveness, authority, and rationality [76–78]. These practices are performed by individuals in a way that reproduces and therefore reinforces gendered aspects of a society or a culture [76,79]. Studies have found that women physics students adopt one of the two roles when confronted by such masculine practices in a male-dominated field—they either distance themselves from and reject femininity completely, by performing masculinities, or they adopt typically feminine roles and traits, such as being diligent, neat, and hard working in an effort to retain their femininity [76,80,81]. Interview data with STEM faculty revealed these women adopted masculine practices, such as being forceful or dominant, rejecting emotionality, and downplaying gender inequality, as they viewed these as more professional than feminine practices [79]. The academic women in our study did not seem to reject femininity completely but instead took on feminine ways of lecturing, by taking a thorough, diligent approach and planning lectures very carefully. This is despite them no longer being students in physics but successful researchers with long careers.

There are several potential reasons why our academic women adopted this approach. First, teaching can be seen as more "feminine" than research, as women do more teaching and academic service than men, while men's focus is on research [10,47,48]. Lecturing may therefore be one way where their femininity can still be performed, even in a male-dominated field such as physics. Researchers have further investigated gender differences in the teaching styles and approaches of lecturers. Women are more likely to use effective teaching strategies such as active learning, compared with men, who are more likely to favor lecturing [82], and are more likely to spend time preparing their teaching materials [83]. While both men and women adopt teaching roles that view students' needs as important, they differ in their teaching styles, with men communicating using a confident and dominant style, while women are more "informal and open" [84]. These differences arise from different beliefs about who is responsible for making teaching and learning decisions—women are more student-centered oriented, while men believe they possess expert knowledge [84]. As academic men are more likely to teach via lecture, and physics as a discipline is characterized by lecturing [82,85], yet teaching in the context of our study was largely constrained to lecturing, the academic women in our study may have felt compelled to perform typically feminine ways of lecturing, such as being conscientious and meticulous.

Second, women have to demonstrate excellence and navigate being both competent and likable in male-dominated environments [28,86]. Thoroughly planning lectures is therefore one way to demonstrate excellence and competence. Indeed, the academic women interviewed in Ref. [87] were also highly conscientious in planning and delivering lectures but were proud of this and felt this approach, in comparison with their male colleagues, was educationally superior for their students.

Third, the academic women in our study displayed imposter syndrome and low levels of self-concept in lecturing, which may also affect their efficacy expectancies and lecture preparation. Comparisons with others' skills, known as the external frame of reference [88], further revealed an inability to identify with a "showman" persona, with a similar finding seen in Ref. [89]. Lecturers generally feel a pressure to be enthusiastic and make their lectures enjoyable and relatable for students [90]. In fields that value brilliance, such as physics, women often feel like imposters [6] thus highlighting a tension between what is expected of them and what they feel they can achieve. For our academic women, being on top of the material, engaging with the students, and delivering good lectures were important. The academic women may have been unable to identify with this persona due to a low physics identity [91]—if being a showman is equated with what you need to do in order to succeed in physics (teaching) in higher education, a lower physics identity moves these academic women away from adopting this persona.

Overall, our academic women may have adopted their meticulous approach due to either a need to perform their femininity, a way to demonstrate competence, or because of low self-confidence. Other reasons within the literature revealed that women regard teaching as more important than men and thus spend more time lecturing, or they want to be a role model, or want to overcome a biased system [87].

Thoroughly planning lectures and distancing themselves away from this charismatic persona are two ways in which gendered practices manifested in our academic women. This is further supported by the findings in [7], where they report on a graduate student taking on a teaching opportunity in which he had no prior experience: "'I'm looking to do some graduate work in mathematics, what can you do for me?' They gave me a job, gave me a syllabus, gave me a textbook, and said, 'You're teaching calculus next week.' So here I am, having never taught a calculus course, being given basically complete control over the course. Just like that. I'm like, 'O.K. I can do this. I can do this.' (p. 1050)." This individual aligns with the spontaneous or improvising persona that our academic women identified as being adopted by their men colleagues.

Student evaluations may reinforce this low self-concept. In terms of service work, academic women are popular and even preferred over men for personal tutor roles, which motivates them to perform well [12]. The picture is different for lecturing; in a study of student evaluations, words meaning spontaneous were used to describe men teachers only [92]. This implies a sense of confidence to turn up and lecture on the spot, which for our academic women was heavily tied to gender. This influence on self-concept is known as balanced identity theory—if the academic women identify strongly with being women, but it is known that women receive poorer student evaluations, this results in low self-concept in their own lecturing abilities [38].

Lecturing an unfamiliar course, or ones with perceived student engagement issues, was seen as undesirable for the academic women—they lacked confidence to take on these opportunities. Women in STEM careers "rely on relational episodes in their lives to create and buttress the confidence that they can succeed in male-dominated domains," [7], such as vicarious experiences and social persuasion. Sarah was so affected by observing a colleague struggle to control the class as this was a potential source of self-efficacy for her—her colleague's unsuccess vicariously reinforced her own self-beliefs that she too would not succeed in teaching similar classes. However, we did not identify social persuasion as a potential source of confidence. Core courses were particularly undesirable, and core course cohorts are much larger than third or fourth year cohorts. Large class sizes are synonymous with lower student engagement, motivation, and quality of lecturer-student interactions [93]. Despite this, the academic women felt the lower engagement was due to the fact these are compulsory courses rather than class size.

The lack of confidence in lecturing an unfamiliar course manifested itself as a perceived increase in the workload. This is because the academic women relied heavily on their content knowledge as a source of confidence. Familiarity with content knowledge is a well-known source of confidence for lecturers [94,95], including the development of extensive and well-organized information to transmit to the students [95]. Novice lecturers rely on content knowledge while experienced lecturers gain confidence that allows them to shift their focus toward pedagogical content knowledge and student-centered approaches [95,96]. However, despite the range of seniority levels of our academic women, it was clear they all relied very heavily on their content knowledge in order to lecture a course well. This, coupled with extensive planning and preparation, translated into an increase in the perceived cost of unfamiliar lecture courses.

Positive past experiences were also important factors, either from their time as students or more recently as lecturers. Hearing the course taught before gave them confidence, and they drew upon these experiences to inform their own teaching practices, a finding also seen in Ref. [97].

The academic women highly valued lecturing in terms of the enjoyment and interactions with students, and other studies have also found teaching is an enjoyable practice to engage in, along with student interactions [98,99]. Intrinsic value is particularly important in physics—students are driven by interest and enjoyment to pursue physics [66]. As expectancies and values for careers such as physics are set in adolescence and school [65], we found that both physics and teaching have an intrinsic value for our academic women, which played out in their passion for the subject and teaching it. The academic women were enthusiastic about teaching, which can have positive effects on students' intrinsic motivation [100]. They also enjoyed the intellectual and creative freedom of lecturing, a finding also shared by Ph.D. students in Ref. [28] regarding research.

The authors in Ref. [50] showed that academics are drawn to the opportunity to develop students' understanding, and the academic women in our study highly valued and understood the importance of developing students' skills and knowledge, as well as providing a unique perspective on the material. Finally, women scientists believe it is important for role models to be gender matched [101], with some of our academic women also valuing the chance to be a role model for the undergraduate women.

A. Limitations

Our study has several limitations. First, our study was limited to one institution and therefore one context. Although we obtained a high response rate from the pool of potential interviewees, our findings only reflect the teaching experiences and motivations of academic women based at our institution. Other contexts may reveal differences in either expectancies for success or what is valued, based on the values of the particular institution and what is emphasized.

Second, we were unable to capture the experiences and motivations of the academic women who chose not to participate, nor did we interview any of the academic men in the department. The experiences and motivations of these two groups of people may also be different, particularly for men. However, although we did not compare directly to the men in order to explore the gendered nature of teaching motivations, some of our findings were explicitly gendered such as the attainment value of being a role model for the undergraduate women, for example.

Third, our study used one theory of motivation, the expectancy-value theory. Other theories of motivation that emphasize other concepts, such as the role of emotions, may have resulted in different interpretations of our findings.

Our study also only focused on one socially constructed identity: gender. Investigating other demographic characteristics, such as ethnicity, and even the intersection of gender and ethnicity, is important to fully understand and address underrepresentation in physics. However, due to

small sample sizes, we were unable to consider this particular intersection.

Finally, our study implied that the academic women's decisions are carried out at the individual level, whereas decisions are likely to be influenced by the gendered nature of academia, and in particular, physics [28].

V. CONCLUSION

Gender plays out in obvious ways in physics regarding research, through competition (securing grants, publishing, and promotions), favoring genius/brilliance, and those without family responsibilities. Our interviews with seven academic women in a department of physics in the United Kingdom have shown that gender can also play out in a subtle way regarding teaching motivations. The academic women navigated a hidden workload of lecture preparation and delivery and self-doubt regarding content knowledge. They lacked the confidence to approach the extra, perceived workload incurred from lecturing an unfamiliar course, suggesting an interplay between costs and expectancies; a high level of expectancy is needed to approach a task with a perceived high cost. This is despite the academic women highly valuing lecturing. The expectancy-value framework was therefore shown to be valuable in allowing us to understand these experiences and our study highlights the importance of using qualitative methodologies when using this framework. Though not always explicitly mentioned by our academic women, our study does highlight how gender is a situative factor in influencing motivation, mediated by the teaching environment and student evaluations. The academic women's motivations were influenced by the gendered structures they had experienced in their careers and as students, such as an inability to identify as a showman, or a desire to be a role model for the undergraduate women.

A. Recommendations and implications

In our study, we set out to understand what motivates academic women physicists to lecture and to lecture particular courses. This understanding can be used to improve the visibility of academic women in physics degree programs. However, it is important to ensure this is not done in a "tokenistic" way.

Our recommendations focus on success criteria and workload. One of the key findings was the low self-concept in lecturing, potentially caused by biased student evaluations. Women in STEM fields face less discrimination if success criteria are clear and well defined, and there is transparency in evaluation processes [102]. We recommend lecturing "job descriptions" to create a level playing field and ensure all lecturers know what to expect and what is expected of them. Pedagogical training should be included within this, to shift the focus away from content knowledge and build confidence [96]. Following this, we further recommend a reevaluation of student evaluations to focus on rewarding learning rather than entertainment, as studies have highlighted a mismatch between perceived and actual learning among students [103]. This would work toward dismantling the emphasis on showmen personas and lecturing needing to be a performance.

The increasing workload in academia means academic women may over time be less likely to lecture, due to its already large workload. However, in the department where this study took place, one of the academic women did report that over time, the timetabling of lectures had improved to consider both workload and family responsibilities: "But what I found out years later was that [the department] have since tried to give better lecturing hours to people with children. They wouldn't now give someone nine o'clock or four o'clock," (Alice). Regardless, we recommend reviewing workloads and providing support for academics to fully manage their teaching duties. One way where this could be realized is the workload involved when taking on a lecture course—previous years' material should be collected, revised, and refined for future use. However, the academic women valued the creative freedom involved, so a balance must be struck between manageable workloads and the agency involved in teaching a lecture course.

The academic women interviewed in our study are passionate and committed to teaching, dedicating a lot of time and effort to lecturing effectively. With the right support systems in place, they can thrive as both teachers and researchers, which can lead to positive consequences for themselves and undergraduate cohorts.

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APPENDIX: INTERVIEW QUESTIONS

List of questions for the semistructured interviews:

1. What courses do you currently lecture, either this academic year or the coming academic year? If you don't currently lecture, what teaching role do you currently have?
2. What courses have you lectured in the past?
3. What motivates you to choose a particular teaching role, such as lecturer, head of year, head of labs, etc?
4. What motivates you to choose a particular lecture course?
5. Is it important to you to lecture a course related to your specialism, and why?
6. What do you think students and the department value in a lecturer? Which of these do you associate with yourself?

[1] Institute of Physics, Physics students in UK Universities Data Brief (2021), https://www.iop.org/sites/default/files/2021-12/Physics-Students-in-UK-Universities-HESA-Data-Brief.pdf.

[2] Institute of Physics, Academic staff in UK physics departments (2020), https://www.iop.org/sites/default/files/2020-07/Staff-characteristics-2017-18.pdf.

[3] Higher Education Statistics Agency, Higher Education Staff Data, https://www.hesa.ac.uk/data-and-analysis/staff/areas.

[4] T. Becher, Physicists on physics, Stud. Higher Educ. **15**, 3 (1990).

[5] J. C. Blickenstaff, Women and science careers: Leaky pipeline or gender filter?, Gender Educ. **17**, 369 (2005).

[6] M. Muradoglu, Z. Horne, M. Hammond, S.-J. Leslie, and A. Cimpian, Women–particularly underrepresented minority women–and early-career academics feel like impostors in fields that value brilliance, J. Educ. Psychol. **114**, 1086 (2021).

[7] A. L. Zeldin, S. L. Britner, and F. Pajares, A comparative study of the self-efficacy beliefs of successful men and women in mathematics, science, and technology careers, J. Res. Sci. Teach. **45**, 1036 (2008).

[8] K. Beddoes and A. L. Pawley, 'Different people have different priorities': Work–family balance, gender, and the discourse of choice, Stud. Higher Educ. **39**, 1573 (2014).

[9] C. Westoby, J. Dyson, F. Cowdell, and T. Buescher, What are the barriers and facilitators to success for female academics in uk heis? A narrative review, Gender Educ. **33**, 1033 (2021).

[10] C. B. K. Howson, K. Coate, and T. de St Croix, Mid-career academic women and the prestige economy, Higher Educ. Res. Dev. **37**, 533 (2018).

[11] C. M. Guarino and V. M. H. Borden, Faculty service loads and gender: Are women taking care of the academic family?, Res. High. Educ. **58**, 672 (2017).

[12] D. E. Pedersen and K. L. Minnotte, University service work in STEM departments: Gender, perceived injustice, and consequences for faculty, Sociol. Focus **51**, 217 (2018).

[13] J. Watts and N. Robertson, Burnout in university teaching staff: A systematic literature review, Educ. Res. **53**, 33 (2011).

[14] E. Fischer and M. Hänze, How do university teachers' values and beliefs affect their teaching?, Educ. Psychol. **40**, 296 (2020).

[15] H. M. Watt and P. W. Richardson, Motivation of higher education faculty: (How) it matters!, Int. J. Educ. Res. **100**, 101533 (2020).

[16] F. Hoffmann and P. Oreopoulos, A professor like me: The influence of instructor gender on college achievement, J. Hum. Resour. **44**, 479 (2009).

[17] S. E. Carrell, M. E. Page, and J. E. West, Sex and science: How professor gender perpetuates the gender gap, Q. J. Econ. **125**, 1101 (2010).

[18] M. E. Tidball, Baccalaureate origins of recent natural science doctorates, J. Higher Educ. **57**, 606 (1986).

[19] S. M. Solanki and D. Xu, Looking beyond academic performance: The influence of instructor gender on student motivation in STEM fields, Am. Educ. Res. J. **55**, 801 (2018).

[20] J. G. Stout, N. Dasgupta, M. Hunsinger, and M. A. McManus, STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM), J. Pers. Soc. Psychol. **100**, 255 (2011).

[21] P. T. Le, L. Doughty, A. N. Thompson, and L. M. Hartley, Investigating undergraduate biology students' science identity production, CBE Life Sci. Educ. **18** (2019).

[22] 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).

[23] K. L. Lewis, J. G. Stout, S. J. Pollock, N. D. Finkelstein, and T. A. Ito, Fitting in or opting out: A review of key social-psychological factors influencing a sense of belonging for women in physics, Phys. Rev. Phys. Educ. Res. **12**, 020110 (2016).

[24] W. Thielens Jr, The disciplines and undergraduate lecturing (1987).

[25] R. Neumann, S. Parry, and T. Becher, Teaching and learning in their disciplinary contexts: A conceptual analysis, Stud. Higher Educ. **27**, 405 (2002).

[26] G. Gibbs, Control and independence, in *Teaching Large Classes in Higher Education: How to Maintain Quality with Reduced Resources* (Routledge, London, 1992), pp. 37–59.

[27] D. F. Treagust and M. Won, Paradigms in science education research, in *Handbook of Research on Science Education* (Routledge, London, 2023), pp. 3–27.

[28] M. Eran-Jona and Y. Nir, Choosing physics within a gendered power structure: The academic career in physics as a "deal", Phys. Rev. Phys. Educ. Res. **17**, 020101 (2021).

[29] K. L. Webber and S. M. Rogers, Gender differences in faculty member job satisfaction: Equity forestalled?, Res. High. Educ. **59**, 1105 (2018).

[30] S. Viefers, M. Christie, and F. Ferdos, Gender equity in higher education: Why and how? A case study of gender issues in a science faculty, Eur. J. Eng. Educ. **31**, 15 (2006).

[31] A. L. Graves, E. Hoshino-Browne, and K. Lui, Swimming against the tide: Gender bias in the physics classroom, J. Women Minorities Sci. Eng. **23**, 15 (2017).

[32] K. Trigwell, M. Prosser, and P. Taylor, Qualitative differences in approaches to teaching first year university science, Higher Educ. **27**, 75 (1994).

[33] A phenomenographic study of academics' conceptions of science learning and teaching, Learn. Instr. **4**, 217 (1994).

[34] K. Samuelowicz and J. Bain, Revisiting academics' belief about teaching and learning, Higher Educ. **41**, 299 (2001).

[35] P. Richardson and H. Watt, Why people choose teaching as a career: An expectancy- value approach to understanding teacher motivation, in *Teacher Motivation*, edited by P. Richardson, S. Karabenick, and H. Watt 1st ed. (Routledge, United Kingdom, 2014), pp. 3–19.

[36] A. Bandura, *Self-Efficacy: The Exercise of Control* (W.H. Freeman and Company, New York, 1997).

[37] A. Bandura, Self-efficacy: Toward a unifying theory of behavioral change, Psychol. Rev. **84**, 191 (1977).
[38] L. Rüschenpöhler and S. Markic, Self-concept research in science and technology education—theoretical foundation, measurement instruments, and main findings, Stud. Sci. Educ. **55**, 37 (2019).
[39] B. C. Hemmings, Strengthening the teaching self-efficacy of early career academics, Issues Educ. Res. **25**, 1 (2015), https://eric.ed.gov/?id=EJ1061117.
[40] D. Chadha, How do we prepare to teach? Exploring science lecturers' authentic approaches to teaching in higher education, Res. Sci. Educ. **52**, 1 (2022).
[41] K. Ismayilova and R. M. Klassen, Research and teaching self-efficacy of university faculty: Relations with job satisfaction, Int. J. Educ. Res. **98**, 55 (2019).
[42] M. da Mota Matos, R. T. Iaochite, and J. G. Sharp, Lecturer self-efficacy beliefs: An integrative review and synthesis of relevant literature, J. Further Higher Educ. **46**, 225 (2022).
[43] D. B. Morris and E. L. Usher, Developing teaching self-efficacy in research institutions: A study of award-winning professors, Contemp. Educ. Psychol. **36**, 232 (2011).
[44] D. Morris, E. Usher, and J. Chen, Reconceptualizing the sources of teaching self-efficacy: A critical review of emerging literature, Educ. Psychol. Rev. **29**, 795 (2017).
[45] T. P. Mottet, S. A. Beebe, P. C. Raffeld, and A. L. Medlock, The effects of student verbal and nonverbal responsiveness on teacher self-efficacy and job satisfaction, Commun. Educ. **53**, 150 (2004).
[46] B. Hemmings and R. Kay, Lecturer self efficacy: Its related dimensions and the influence of gender and qualifications, Issues Educ. Res. **19**, 243 (2009), https://eric.ed.gov/?id=EJ868650.
[47] S. Winslow, Gender inequality and time allocations among academic faculty, Gender Soc. **24**, 769 (2010).
[48] C. Myers, College faculty and the scholarship of teaching: Gender differences across four key activities, J. Scholarship Teach. Learn. **8**, 38 (2008), https://eric.ed.gov/?id=EJ854841.
[49] A. L. Zeldin and F. Pajares, Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers, Am. Educ. Res. J. **37**, 215 (2000).
[50] E. Bexley, S. Arkoudis, and R. James, The motivations, values and future plans of Australian academics, Higher Educ. **65**, 385 (2013).
[51] R. O. Guillaume and M. T. Kalkbrenner, The utility of self-determination theory in faculty of color's successful pursuit of tenure and promotion to the rank of associate professor, Int. J. Educ. Res. **98**, 272 (2019).
[52] M. Daumiller, R. Stupnisky, and S. Janke, Motivation of higher education faculty: Theoretical approaches, empirical evidence, and future directions, Int. J. Educ. Res. **99**, 101502 (2020).
[53] M. Daumiller and M. Dresel, Teaching and research: Specificity and congruence of university faculty achievement goals, Int. J. Educ. Res. **99**, 101460 (2020).
[54] K. Thies and R. Kordts-Freudinger, German higher education academic staff's positive emotions through work domains, Int. J. Educ. Res. **98**, 1 (2019).
[55] A. Wigfield, Expectancy-value theory of achievement motivation: A developmental perspective, Educ. Psychol. Rev. **6**, 49 (1994).
[56] A. Wigfield and J. S. Eccles, Expectancy–value theory of achievement motivation, Contemp. Educ. Psychol. **25**, 68 (2000).
[57] J. Eccles and A. Wigfield, Motivational beliefs, values and goals, Annu. Rev. Psychol. **53**, 109 (2002).
[58] J. Eccles, Expectancies, values and academic behaviors, in *Achievement and Achievement Motives*, edited by J. T. Spence (W. H. Freeman and Company, San Francisco, 1983), Chap. 2, pp. 75–146.
[59] R. M. Ryan and E. L. Deci, Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions, Contemp. Educ. Psychol. **61**, 101860 (2020).
[60] E. Q. Rosenzweig, A. Wigfield, J. S. Eccles, K. A. Renninger, and S. E. Hidi, Expectancy-value theory and its relevance for student motivation and learning, in *The Cambridge Handbook of Motivation and Learning, Cambridge Handbooks in Psychology* (Cambridge University Press, Cambridge, England, 2019), pp. 617–644.
[61] G. D. Ceyhan and J. W. Tillotson, Early year undergraduate researchers' reflections on the values and perceived costs of their research experience, Int. J. STEM Educ. **7**, 54 (2020).
[62] M. V. Bøe, E. K. Henriksen, T. Lyons, and C. Schreiner, Participation in science and technology: Young people's achievementrelated choices in latemodern societies, Stud. Sci. Educ. **47**, 37 (2011).
[63] M.-T. Wang and J. Degol, Motivational pathways to stem career choices: Using expectancy–value perspective to understand individual and gender differences in STEM fields, Dev. Rev. **33**, 304 (2013).
[64] C. J. Fong, K. P. Kremer, C. Hill-Troglin Cox, and C. A. Lawson, Expectancy-value profiles in math and science: A person-centered approach to cross-domain motivation with academic and stem-related outcomes, Contemp. Educ. Psychol. **65**, 101962 (2021).
[65] J. Eccles and M.-T. Wang, What motivates females and males to pursue careers in mathematics and science?, Int. J. Behav. Dev. **40**, 100 (2015).
[66] 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).
[67] K. Drossel, B. Eickelmann, S. van Ophuysen, and W. Bos, Why teachers cooperate: An expectancy-value model of teacher cooperation, Eur. J. Psychol. Educ. **34**, 187 (2018).
[68] A. Darby and L. Willingham, Faculty motivation in service-learning based on expectancy x value theory, J. Exp. Educ. **45**, 337 (2022).
[69] C. Kuhn, G. Hagenauer, and A. Gröschner, "Because you always learn something new yourself!" an expectancy-value-theory perspective on mentor teachers' initial motivations, Teach. Teach. Educ. **113**, 103659 (2022).
[70] J. S. Eccles and A. Wigfield, From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation, Contemp. Educ. Psychol. **61**, 101859 (2020).

[71] S. B. Nolen, A situative turn in the conversation on motivation theories, Contemp. Educ. Psychol. **61**, 101866 (2020).
[72] J. Creswell and C. Poth, *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (Sage, California, 2016).
[73] J. Fereday and E. Muir-Cochrane, Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development, Int. J. Qual. Methods **5**, 80 (2006).
[74] V. Braun and V. Clarke, Using thematic analysis in psychology, Qual. Res. Psychol. **3**, 77 (2006).
[75] V. Braun and V. Clarke, Reflecting on reflexive thematic analysis, Qual. Res. Sport Exercise Health **11**, 589 (2019).
[76] A. T. Danielsson, Exploring woman university physics students 'doing gender' and 'doing physics', Gender Educ. **24**, 25 (2012).
[77] A. 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).
[78] A. J. Gonsalves, A. Danielsson, and H. Pettersson, Masculinities and experimental practices in physics: The view from three case studies, Phys. Rev. Phys. Educ. Res. **12**, 020120 (2016).
[79] L. A. Rhoton, Distancing as a gendered barrier: Understanding women scientists' gender practices, Gender Soc. **25**, 696 (2011).
[80] K. N. Quinn, M. M. Kelley, K. L. McGill, E. M. Smith, Z. Whipps, and N. G. Holmes, Group roles in unstructured labs show inequitable gender divide, Phys. Rev. Phys. Educ. Res. **16**, 010129 (2020).
[81] D. Doucette, R. Clark, and C. Singh, Hermione and the secretary: How gendered task division in introductory physics labs can disrupt equitable learning, Eur. J. Phys. **41**, 035702 (2020).
[82] T. F. Nelson Laird, A. K. Garver, and A. S. Niskodé-Dossett, Gender gaps in collegiate teaching style: Variations by course characteristics, Res. High. Educ. **52**, 261 (2011).
[83] E. R. Singer, Espoused teaching paradigms of college faculty, Res. High. Educ. **37**, 659 (1996).
[84] C. H. Lacey, A. Saleh, and R. Gorman, Teaching nine to five: A study of the teaching styles of male and female professors, in *Presented at the Annual Women in Educational Leadership Conference, Lincoln, Nebraska* (1998).
[85] S. LindblomYlänne, K. Trigwell, A. Nevgi, and P. Ashwin, How approaches to teaching are affected by discipline and teaching context, Stud. Higher Educ. **31**, 285 (2006).
[86] M. Heilman and T. Okimoto, Why are women penalized for success at male tasks?: The implied communality deficit, J. Appl. Psychol. **92**, 81 (2007).
[87] L. Carson, Gender relations in higher education: Exploring lecturers' perceptions of student evaluations of teaching, Res. Pap. Educ. **16**, 337 (2001).
[88] H. W. Marsh, Verbal and math self-concepts: An internal/external frame of reference model, Am. Educ. Res. J. **23**, 129 (1986).
[89] C. Hockings, S. Cooke, H. Yamashita, S. McGinty, and M. Bowl, 'I'm neither entertaining nor charismatic…' negotiating university teacher identity within diverse student groups, Teach. Higher Educ. **14**, 483 (2009).
[90] B. Wong and Y.-L. T. Chiu, Let me entertain you: The ambivalent role of university lecturers as educators and performers, Educ. Rev. **71**, 218 (2019).
[91] Z. Y. Kalender, E. Marshman, C. D. Schunn, T. J. Nokes-Malach, and C. Singh, Gendered patterns in the construction of physics identity from motivational factors, Phys. Rev. Phys. Educ. Res. **15**, 020119 (2019).
[92] J. Sprague and K. Massoni, Student evaluations and gendered expectations: What we can't count can hurt us, Sex Roles **53**, 779 (2005).
[93] C. Mulryan-Kyne, Teaching large classes at college and university level: Challenges and opportunities, Teach. Higher Educ. **15**, 175 (2010).
[94] G. S. ÅKerlind, Growing and developing as a university teacher–variation in meaning, Stud. Higher Educ. **28**, 375 (2003).
[95] I. Sadler, The role of self-confidence in learning to teach in higher education, Innov. Educ. Teach. Int. **50**, 157 (2013).
[96] S. P. Fraser, Pedagogical content knowledge (PCK): Exploring its usefulness for science lecturers in higher education, Res. Sci. Educ. **46**, 141 (2016).
[97] A. Oleson and M. T. Hora, Teaching the way they were taught? Revisiting the sources of teaching knowledge and the role of prior experience in shaping faculty teaching practices, Higher Educ. **68**, 29 (2014).
[98] L. Postareff and S. Lindblom-Ylänne, Emotions and confidence within teaching in higher education, Stud. Higher Educ. **36**, 799 (2011).
[99] G. Hagenauer and S. Volet, 'I don't think i could, you know, just teach without any emotion': Exploring the nature and origin of university teachers' emotions, Res. Pap. Educ. **29**, 240 (2014).
[100] B. C. Patrick, J. Hisley, and T. Kempler, 'What's everybody so excited about?": The effects of teacher enthusiasm on student intrinsic motivation and vitality, J. Exp. Educ. **68**, 217 (2000).
[101] G. Buck, V. Clark, D. Pelecky, and Y. Lu, Examining the cognitive processes used by adolescent girls and women scientists in identifying science role models: A feminist approach, Sci. Educ. **92**, 688 (2008).
[102] 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).
[103] L. Deslauriers, L. McCarty, K. Miller, K. Callaghan, and G. Kestin, Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom, Proc. Natl. Acad. Sci. U.S. A. **116**, 19251 (2019).