Identifying strengths and areas for improvement in a new physics Ph.D. program

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STEM graduate programs continue to have low retention rates, with first-year experiences being critical in student persistence. This study examines the experiences of the inaugural cohort of a physics Ph.D. program at a private R2 university. A focus group interview with four of the seven students in the cohort was conducted using a semi-structured interview protocol, and the transcript was analyzed with deductive thematic analysis methods. Students found value in program aspects including their relationships with research mentors, a supportive and collaborative atmosphere, and graduate course credit transfer. Desired program changes included more structured social integration, clearer department communication, and improving required courses. These findings will be incorporated into a larger study on the climate and culture of the physics department, and will be presented to faculty leaders to help establish the regular use of student data to inform gradual program improvement early in the existence of the program.

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I. INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) education continues to struggle with significant disparities in gender, race, and ethnicity across all levels of education [1, 2] and low retention rates [2]. Among STEM disciplines, physics stands out as one of the least diverse [3]. These disparities reflect the long history of exclusion faced by American women, African Americans, Hispanic Americans, and Native Americans from participation in economic, political, and cultural institutions. The lack of diverse representation in STEM is one of the continuing consequences of this systemic exclusion [4].

In the last few years, several large-scale initiatives have taken place to support physics programs becoming more diverse (e.g., [5, 6]). For example, Bridge-to-the-Doctorate programs were developed to shorten the gap between students' participation at the undergraduate and doctoral levels [7, 8] by building a structure to ensure that students in bridge programs attend departments with supportive resources [7].

Despite significant efforts and resources devoted to improving diversity and retention rates, widespread progress has yet to be observed [9]. A critical shortcoming of many of these initiatives is their strong focus on structural changes, often without corresponding attention to the deeper cultural elements that shape student experiences and their sense of belonging. For example, research on students in bridge programs in research intensive institutions shows that these students often face exclusionary behaviors such as microaggressions and resentment from their peers [10]. Meaningful and lasting change, especially change that influences multiple areas within departments, requires a transformation in the culture - specifically, in shared understandings of what is valued and how individuals are expected to act [11–13]. In other words, to increase diverse participation and improve retention for all students, those leading change must move beyond adjustments to program structures and actively foster a more welcoming and supportive academic environment.

In complex settings such as academic institutions, efforts to create lasting improvement are more likely to succeed when cultural change is intentional and integrated into the process [14, 15]. Achieving this requires engaging in an ongoing process of data collection, reflection, and action [16, 17].

Although many programs recognize that improving retention is a critical priority, there is currently no consistent or systematic method for tracking the reasons for why students choose to leave. Often students depart quietly, without voicing the dissatisfaction or challenges that ultimately influence their decision to withdraw from the program [18]. Even in cases where programs administer exit surveys, the responses are rarely reviewed or used to inform meaningful change. Furthermore, there is a clear disconnect between the factors that faculty believe lead to attrition and research findings related to attrition [4]. Two studies with graduate students and faculty showed that students attributed attrition to departmental factors, such as lack of social and academic support, inadequate advising, financial support. At the same time, none of the faculty members attributed attrition to any departmental factors; they believed that student factors caused attrition [4, 19].

This paper examines a newly established physics doctoral program that welcomed its first cohort in Fall 2024. Aiming to avoid the structural and cultural pitfalls common in traditional physics programs, we decided to prioritize a culture of continuous improvement through systematic data collection, collective reflection, and responsive action. To support this effort, researchers initiated this longitudinal study to document and understand the student experience over time, as well as to identify ways the program can more effectively support student success, well-being, and a sense of belonging. The research question (RQ) we aim to address in this paper is:

What supports, challenges, and structural elements do students in the first cohort of a newly developed physics doctoral program identify, and how do they describe areas of strength and areas for improvement within the program?

II. METHODS

A. Educational context

This study took place at a private R2 university in the northeastern United States. The department has long offered Astronomy MS and Ph.D. programs and added a Physics MS in 2019 and a Physics Ph.D. in 2024. The first year for students admitted to the Physics Ph.D. program consists of graduate coursework, conducting research overseen by a faculty advisor, and teaching assistant duties. Required coursework includes selecting four out of five core graduate physics courses, two semesters of a graduate seminar course, and four elective graduate courses. Students must earn a B or higher in core courses to skip a written comprehensive exam in those subjects. The program also requires a qualifying exam with a written research report and oral defense by the end of the second year. Upon passing the qualifying exam, the student progresses to Ph.D. candidacy, which culminates in a written dissertation and oral defense.

The new Ph.D. program began with seven students from diverse academic backgrounds, most holding MS degrees from other institutions. Many transferred core course credits, making graduate seminars the only shared class. Those with MS degrees were expected to take qualifying exams by the end of their first year. All students had research advisors and groups in place before starting, with some being funded through research immediately. Most received TA funding for the first year, though some secured research positions by Spring 2025.

B. Procedures and Analysis

The main source of data for this paper was a 90-minute focus group interview that was conducted using a semi-structured interview protocol that took place in the last week of the Spring 2025 academic semester. A focus group was chosen over one-on-one interviews to create a more comfortable atmosphere with natural conversation between peers [20, 21]. The interview protocol was developed based on prior work in the field of graduate education research [22–26], but was mainly based on the items and factors in the Aspects of Student Experiences Scale (ASES) survey [22]. The protocol began by discussing the overall experiences of the students, but also included questions in the specific categories of social integration, mental health, coursework, research experience, professional development, TA experiences, and financial support. These specific categories and their questions were subsequently used as the basis for the codebook for analyzing the transcripts.

The interview participants were four of the seven physics Ph.D. students in the inaugural class of the program. The small number of physics Ph.D. students in this program means that any demographic data is potentially identifying to participants, thus these data have been omitted from this paper. Supplementary data was collected from written responses that were part of the ASES survey distributed to all graduate students in the physics department. Three out of the four focus group participants completed the survey, and their responses were included in this study.

After removing all identifying information, the focus group interview audio was transcribed using an AI-based transcription program. The resulting transcript was manually reviewed for accuracy against the original audio recording. Both the cleaned focus group transcript and the qualitative survey responses were then coded with a first-pass deductive coding process, using the software Dedoose. Common themes in the codes were identified using thematic analysis methods [27].

III. RESULTS

Applying the codebook in a deductive manner to both the focus group interview transcript and the qualitative written survey responses led to several emerging themes. These themes have been sorted into program aspects that the students found valuable to their experiences, and features that were perceived as needing improvement or change.

A. Valuable Program Aspects

1. Sense of Belonging and Positive Atmosphere: The interviewed students described an overall positive atmosphere and sense of belonging within the program, specifically in reference to interactions with faculty and staff. The culture of the program was viewed as more supportive and collaborative when compared to previously attended institutions, exemplified in the following excerpts:

> "I think the culture here is really nice, compared to the old ones [I've been to]. It has a really supportive culture for the most part." - Allen

> "I just think the department is shockingly healthy for a physics department. From a lot of my experiences and from what my friends at grad schools have said, it just seems like there's a really good air of cooperation here, of teamwork, of actually trying to help each other. - Chris

> "Compared to my previous school, the campus is much more diverse - lot of different programs, lot of different students from a lot of different backgrounds. I love it." - Dawn

While the departmental culture was perceived as supportive and positive, the interviewed students did not think that there were any particular policies or actions taken by department leadership in this regard, but rather that it was an organic program aspect.

2. Mentors and Research Advisors: The students in the interview described strong and supportive relationships with their research advisors throughout their experiences in the program, beginning during the recruitment process. Three students expressed that their eventual research advisors were one of the main factors that influenced their decision to attend this Ph.D. program. These faculty were active in the recruiting of prospective students to their research groups via email and interviews before they had applied for the program. These efforts and communications left strong positive impressions on the students regarding the potential to work with these faculty toward their Ph.D. The students' research mentors were described as having high expectations for their work, but also being flexible and understanding if struggles were occurring. These faculty were also cited as sources of support for the students' mental health:

> "I do feel like I am more able to talk with my professors here. Like if I'm having a problem, I feel like I can actually address that with them instead of sort of beating around the bush. - Chris

The overall working relationships with faculty mentors were viewed as positive and productive. When asked about the prospect of switching advisors and research groups, it was expressed that that there were no perceived barriers from either the department or faculty besides the availability of funding. All four students expressed that they had no plans to switch groups at the time of the interview.

3. Collaborative and Interdisciplinary Research: The wide variety of research topics available to the students was viewed as a program highlight. When prompted to discuss what they found valuable in their first year in the program, one student said:

> "Collaboration for sure, not just within the [physics] department, but within the college as a whole. I just feel like it's one big group of people

> working on various research topics, and sharing expertise with each other. - Chris

The rest of the students echoed this sentiment, describing their own experiences working with other research groups across multiple disciplines and at different institutions.

4. Program Flexibility/Transferring of Credits: The students also expressed an appreciation for the Ph.D. program allowing them to transfer graduate class credits from their previous institutions. When prompted for program strengths, a survey response read:

> "I am glad that I was able to transfer a lot of my work that I had done while getting my MS, which I do not think I would have been able to do nearly as much elsewhere." - Allen

Another student expressed a similar view during the focus group interview:

> "I like the fact that [the program] is flexible. If you're coming in with your master's, the program head talks with you [and says]: 'you have these many courses, so you don't have to take [them] again.' So depending on your background, they customize and tailor the program for you." - Brandon

The overall sentiment was that this policy could save a significant amount of time toward graduation, and that other programs might not share this feature.

B. Needed Program Changes or Improvements

1. Weaker Sense of Community Within First Cohort: A consistent theme throughout the focus group interview was a perceived lack of structured social events and interactions within the physics Ph.D. cohort. Many of the students in the cohort were not taking the same courses due to transferring of credits from other institutions, shown in this exchange between students:

> "Because I don't take classes I just get to see everybody only during the grad seminars. [...] Outside of that, I see very few people." - Dawn
>
> "This is why I'm advocating for more events. Because I'm not in any classes [or] graduate seminar, so this is more interaction with my peers [than] I've had all semester, and I would like to change that." - Chris

Students also noted that structured department events did not need to include the entire physics faculty and student body, citing their tendency toward introversion at times. Smaller events like Ph.D. cohort lunches or trivia nights were discussed as events that could be supplementary to larger department functions.

The physics department at this institution is spread out between several academic buildings, and the students expressed that this affected the social aspect of the program.

> "Yeah, I think it does. If people are gathering in [the other building] to work on stuff or just talk and hang out, I'll really not have much access to that. If it was here [in this building], then I'd be more aware of it. [...] The fact that the shared space is on the other side of campus just sort of makes it not worth it." - Chris

Students also noted a lack of common spaces on campus for graduate student interaction, such as desk space or a student room. One survey response stated that they would like to see senior graduate students assigned as peer mentors to incoming students in the future.

2. Needed Clarity on Program Expectations and Logistics: A common issue that was discussed during the focus group interview was a feeling that some communication of program expectations were vague or lacking both before and during the first year of the program. A major contributor to this feeling was a lack of graduate student handbook with policies and a timeline of milestones for students to hit. Many of these program expectations were discussed in the graduate seminar in the fall semester, but were never formally written down and distributed. The following exchange occurred when students were asked about program aspects that need improvement:

> "It's probably because [the program] is new - I think it's the handbook. [...] There's no guidebook on what you need to do to get the Ph.D.. Something you can just reference, that would be good to have." - Allen
>
> "Yeah, right now it just feels totally open ended. I have no idea where I'm going to be a year from now. Like I'm here, obviously, but what will I be doing? I have no idea." - Chris

Much of the uncertainty in the future for the students was centered around funding, especially those working as TAs for the first year. One survey response read:

> "I will say that there were some things that I was told before coming in, that were untrue or that the department was less sure of than they presented initially. One was the availability of TA work during the Summer (with it seeming like a definite opportunity before entering and then being very unlikely after joining)" - Allen

Students overall felt a lack of clear communication from the department regarding certain program logistics.

3. Lack of Professional Development Opportunities: A major theme that emerged through the focus group interview was a consensus that the department did not provide enough professional development opportunities for the Ph.D. cohort.

When asked about program aspects that need improvement, one student said:

> "Professional development opportunities, would love to see more of those. I would like to see personalized professional development, like a mentor or somebody to talk to who [...] can make you aware of what opportunities are out there, what career options you have, what can you do with your degree." - Dawn

The focus group also felt that most of the professional development available to them was centered around preparation for a career in academia. As stated by one student:

> "I thought the industry speaker this semester was really good, because he was also an alumnus from here. So, he was someone who knew this place, got skills from this place, and then went off and was successful in industry. So how do you do that? I would like to meet more people like that and hear how they did it." - Chris

The students generally felt that the department could be doing more to help them in their career readiness and planning.

4. Coursework Generally Not Relevant to Research: The interviewees that had taken coursework at this institution expressed some frustrations with the structure, pedagogy, and content of those core courses. Being prompted about their experiences with coursework, Brandon mentioned:

> "I think there's too [few] courses that's offered here for graduate requirement. You have to pick four out of five courses, which none (heavily emphasized) of them are related to what I'm doing, and all of them are like a slight upgrade from undergrad courses." - Brandon

Other issues included a lack of active learning pedagogy and negative experiences with certain textbooks like *Classical Electrodynamics* by J.D. Jackson [28]. There was also a portion of conversation devoted to the graduate seminar courses, which were built around introducing students to potential research advisors. While this structure worked well for students without identified advisors, this particular cohort of Ph.D. students had advisors matched prior to joining the program. The consensus was that the seminar could have been better used for the Ph.D. students to advance professional skills.

5. Guidance with Finances and Benefits: The participants expressed having uncertainty regarding financial matters. The students' financial needs are generally being met under current stipend support, but they have not been able to put any money into savings. All of the students were living in off-campus housing, with some having roommates to cut costs. Transportation to and from campus is an issue for some, as navigating the area around the university without a car has proven difficult. One student mentioned that they wished the university had a graduate student union, as they had received an offer from another institution that has such a union, along with higher stipend pay. International students also noted that institutional support would be helpful to navigate the U.S. tax system.

IV. DISCUSSION & CONCLUSIONS

The themes that emerged from this analysis offer a glimpse into the experiences of students in the inaugural class of the physics Ph.D. program at this institution. Overall, students had a positive view of their first year, especially in terms of their interactions with faculty and their research mentors. Department communications, professional development, and more structured social events were aspects that were frequently mentioned as in need of improvement. Transferring graduate class credits from previous programs was commonly identified as a positive aspect, and while it did help students save time toward graduation, it also had the potential consequence of a weaker sense of camaraderie among this first Ph.D. cohort due to the lack of common structured classes.

The themes of mentorship, sense of belonging, and program flexibility are consistent with prior research highlighting their critical role in graduate student satisfaction, retention, and mental health [29]. Gaps in professional development, social integration with peers, and clarity in program expectations reflect well-documented challenges in graduate education, reinforcing calls for structured support beyond academic training [30].

The work presented in this paper is part of a larger study on the climate and culture of the physics graduate program at this institution. A future paper will present the analysis across multiple focus groups and surveys (astronomy Ph.D. and physics MS students) to better understand the cultural elements of the department that are tied to the ways that the physics and astronomy programs are designed. Finally, we note that we plan to generate a report to the department and discuss the findings with faculty and students in an effort to begin a cycle of using collected student data to inform program changes and improvements over time. We would like to acknowledge and thank all focus group interview participants for their time and invaluable insights.

V. LIMITATIONS

This study focuses on a single Ph.D. program, and thus the analysis and conclusions are specific to only this context. The sample size of 4 students limited the number of viewpoints that could be captured within the data. Inter rater reliability (IRR) was not conducted for the analysis presented in this paper, but will be incorporated into planned follow up publications. We also acknowledge that this study lacks the viewpoints and experiences of faculty and other stakeholders in the department.

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