# Projections as Preparation for Persistence: Exploring Expectations for Engineering Graduate School

**Ellen Zerbe, Pennsylvania State University, University Park**

Ellen Zerbe is a Ph.D. candidate in Mechanical Engineering at Pennsylvania State University. She earned her B.S.M.E. at Grove City College. She is currently researching under Dr. Catherine Berdanier in the Engineering Cognition Research Laboratory.

**Gabriella M Sallai, Pennsylvania State University**

Gaby Sallai is currently a Master's student in the mechanical engineering department at Penn State. She is working under Catherine Berdanier in the Engineering Cognitive Research Laboratory (ECRL). She received her Bachelor's degree from Franklin & Marshall College in physics and women and gender studies.

**Dr. Catherine G.P. Berdanier, Pennsylvania State University, University Park**

Catherine G.P. Berdanier is an Assistant Professor in the Department of Mechanical Engineering at Pennsylvania State University. She earned her B.S. in Chemistry from The University of South Dakota, her M.S. in Aeronautical and Astronautical Engineering and Ph.D. in Engineering Education from Purdue University. Her research interests include graduate-level engineering education, including inter- and multidisciplinary graduate education, online engineering cognition and learning, and engineering communication.

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## Abstract

The purpose of this research paper is to explore the expectations that engineering students have when entering graduate school. Graduate engineering education is understudied, but recent reports have highlighted the importance of focusing on topics related to graduate student retention and thriving. Our team's recent work explored how graduate students have come to engineering and, more importantly, captured why they may be considering departing from their graduate studies, finding that students' expectations and goals for graduate school are more important than previously established: Students coming in with uncertain goals and expectations often consider departing from their PhD programs. This paper presents interviews with N=35 current engineering graduate students, exploring their perceptions for what they thought graduate school would be like. The semi-structured interview protocol probed students to think back on their transitions into their graduate programs, expectations for the graduate school experience, and whether those expectations were proven false or were validated. Findings show that those students whose expectations were incorrect and resulted in negative experiences were more likely to consider leaving their programs later in their career as a graduate student. This work adds to the relatively scarce body of literature on graduate level engineering education and will influence theory development to add to the national conversations on graduate-level completion and departure from the engineering PhD.

## Introduction and Literature Review

Attrition at the graduate level is an important issue faced by universities, yet it remains a complex phenomenon that is not completely understood. While attrition is difficult to quantify, because of the way attrition is counted or reported by different universities, studies estimate that forty to sixty percent of doctoral students leave their program in some disciplines [1]. Within engineering, factors such as academic culture [2], academic capabilities [3], and race and gender [4]–[6] have all been attributed to attrition and persistence. While some studies offer recommendations for addressing this issue [7]–[9], attrition remains complex, with many different factors that affect each individual's decision.

Graduate student well-being has become an increasing concern in many different disciplines as attrition rates are indicative of underlying issues, such as mental health or departmental culture not accounted for in external indicators of success such as GPA. In many studies on attrition, the student's relationship with their advisor and student socialization have been used as factors representing well-being [10]–[13]. Castello et al. [2] found that, among doctoral students considering leaving their program, work-life balance and integration into the scientific community were cited as the two most common factors in driving them to leave. Issues related to relationships with the advisor, department, and the scientific community as a whole are mentioned as negatively impacting the students' experiences in graduate school.

While external factors may be at play, few studies have researched how students' initial expectations for graduate school impact their experiences. In a case study of two "questioners"

(students who are seriously considering leaving their graduate programs) in engineering graduate programs, the results showed that academic capability and advisor relationships were not major factors in each student's decision to leave [14]. Instead, mismatched expectations for what their graduate school experience would be like and conflicting personal and professional identities influenced their decision process. Peters and Daly [15] studied engineering students who returned to graduate school after working for a time, showing that the utility of the degree was a major driving force in persistence. The decision to stay in the degree was viewed through an analysis of costs, saying that "the question was not whether they could successfully complete a graduate degree program but whether it was worth doing" (p. 262). A more comprehensive model of the attrition decision process was developed by Berdanier et al. [16]. The GrAD model not only exposed the major factors in engineering graduate student attrition, it also showed the interconnectedness of each of the factors and demonstrated how the decision process is complex and nuanced. Major themes in the model were "Advisor Role and Relationship," "Support Network," "Quality of Life and Work," "Cost," "Perception by Others," and "Goals." The connection between these themes and subsequent subthemes were analyzed through narrative analysis of anonymous posts about graduate level attrition on Reddit. These studies are examples of how factors influencing attrition vary. When the student's expectations for graduate school are mismatched with their experiences, it lays the groundwork for many other common factors relating to attrition. This work focuses on engineering graduate students' expectations for graduate school, how they have compared to their experiences, and their current expectations for continuing in their programs. As such, this study seeks to address the following research questions:

1. What preconceptions of graduate school do engineering students have?
2. Are students who had inaccurate preconceptions of graduate school more likely to consider leaving their program early?

**Theoretical Framework**

This study uses a combination of two theoretical frameworks to interpret the results: Socialization theory and the Met Expectations Hypothesis. Socialization, as it pertains to graduate students, goes beyond integrating into a community; it also refers to the preparation for a profession, typically academia [17], [18]. Golde [7] describes socialization for graduate students in four parts: intellectual mastery, adjustment to life as a graduate student, understanding of the profession, and integration into the department. Each student experiences these facets of socialization differently and, therefore, the socialization process is individualized. For the purposes of this study, the aspects of the socialization process involving adjustment to life as a graduate student and understanding the profession are the most relevant.

The second theoretical framework we use in this study is the Met Expectation Hypothesis (MEH). MEH has typically been applied in human resource management regarding employee satisfaction [19], [20]. The theory suggests that a confirmation of an employee's expectations for a new job leads to higher job satisfaction later, thereby reducing the likelihood of turnover. Hughes et al. [21] adopted this hypothesis for graduate students. In their study, they used MEH to assess graduate students' satisfaction with a course. Expanding this application, we replace 'employee' with 'graduate student;' instead of 'job,' we use 'graduate school;' and instead of 'turnover,' we focus

on 'attrition.' For the purposes of this study, the MEH now suggests that a confirmation of a student's expectations for graduate school would lead to reduced likelihood of attrition.

**Methods**

This study is part of a larger NSF-funded study that focuses on the hidden socialization processes for engineering graduate students, such as academic writing, that may correlate with attrition and persistence [22]–[24]. As part of that study, administrators of engineering departments at ten R1 universities across the U.S. were contacted and asked to forward a survey to their engineering graduate students in both PhD and Master's programs. More information about the survey and its results can be found in previous work by authors [22]–[24]. Participants in the survey were also asked if they would be interested in participating in an interview about their experiences with academic writing and overall experiences in graduate school. Maximum variation sampling was used to select from the pool of interested participants. Participants were selected for diversity in gender, ethnicity, discipline, and stage in graduate school. A pool of N=35 students participated in an interview. The sample was split 18 males and 17 females. 22 participants identified as White, 5 identified as Hispanic, 2 identified as Asian, 1 identified as African American, and the rest identified as two or more ethnicities. Figure 1 displays the academic level of the participants at the time of the interview. In the interview, we asked about their path to graduate school, their preconceptions of graduate school compared to their experiences, their career goals, and their experiences with academic writing. Each interview was about an hour long, conducted online, and recorded via Zoom. Participants were given a $15 Amazon gift card for their time. Transcriptions were created through a professional transcription service and a team member checked them for accuracy, redacted any identifiable information, and assigned pseudonyms. Analysis of the transcripts was done in NVivo 12 through open and axial coding to find emergent themes that were relevant to the proposed research questions. The excerpts were coded to consensus between two researchers.
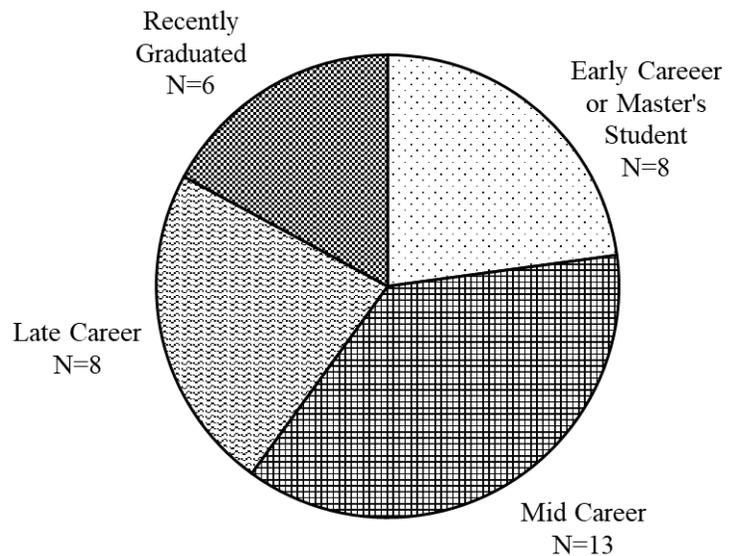


*Figure 1: Academic level of participants. Early career includes students in their first or second year of graduate school and all Master's students. The category 'Mid-career' includes students in their third or fourth year, and 'later career' includes students in their fifth year or greater.*

**Limitations**

The results presented in this study represent the experiences of only 35 engineering graduate students. The study design likely includes elements of self-selection bias, where only students who are ready and willing to talk about their experiences volunteered for the interview. Students who

may have had more challenging experiences in graduate school may not have felt comfortable with sharing that information in an interview and, therefore, their stories are not represented. We attempted to gather the greatest variety of experiences by doing maximum variation sampling when selecting our participants. This led to an oversampling of women (nearly half of the sample) compared to the average ratio of women to men in graduate engineering programs (about 73% male in Master's degree programs and about 76% male in PhD programs [25]). If we had chosen the participants at random, we likely would have had a more homogenous grouping with potentially similar experiences.

**Results**

During the analyses of the interview transcripts, for the purposes of this study, we focused on instances where the participant discussed the preconceptions they had about graduate school before starting as well as their thoughts on leaving their program. We present these results in three categories: Expectations for graduate school, Attitudes toward Expectations; and Attitudes toward Attrition.

**Expectations for Graduate School**

*1. Expectation: Poor Quality of Life*

Participants who believed they would have a poor quality of life in graduate school expected to be depressed and stressed, be isolated, encounter distant professors, and/or be in a competitive environment. Some participants, like Francois and Olivia, assumed being a graduate student meant spending every waking moment in a lab doing research, with Francois going so far as to liken her expectations of being a graduate student to slavery:

> *"I think that I thought that I would be way more like a slave. I think, there is the pre-conception that, you'll be in the lab all day long and you won't really have a social life."*
> *— Francois (fifth year graduate student)*

Other participants, including Kelsey, explicitly referred to mental health and expecting to deal with a mental illness while in graduate school:

> *"I hear a lot of people casually joke about having depression and anxiety in grad school, which is very real. And I don't find it funny having struggled with that very much myself, but I think people assume that it's just part of being a grad student to feel like you're slogging through and not really know when the end is gonna be coming.."—Kelsey (third year graduate student)*

They also acknowledged a preconceived idea of feeling isolated in graduate school. Victor noted that:

> *"I think I was roughly aware of how lonely it can be."—Victor (fourth year graduate student)*

Participants seemed to be aware of the overwhelming mental health issues among graduate students [26], [27] and expected to struggle with being over-worked, stressed, and depressed.

Corroborations of this idea was expressed in 12 of the interviews; 15 interviewees expected some element of a poor quality of life.

2. *Expectation: Ideal Academia*

Some participants entered graduate school expecting it to be an ideal environment for research and learning. Those participants who expected an ideal academic setting believed they would have control over their work, the graduate school environment would be relaxed, people would be focused and passionate, and/or there would be less work overall. One of the participants, Aquinas, compared the passion he expected in graduate school to childhood curiosity, where everything is new, interesting, and worth trying to understand:

> *"I was definitely expecting, but I eventually ended up seeing that the level of passionateness about everything was heightened compared to undergrad, where undergrad seemed to be, and I don't know if this is universal for other students, but at least for me, it seemed that people were very much like, "I just wanna get as many points as I can so I can graduate and get a job." Whereas, here people are studying what they're generally passionate about and what they wanna see themselves doing for the rest of their life. It's almost like returning to a place where people had that childhood curiosity."—Aquinas (third year graduate student)*

Franklin believed graduate school would be a more "chill" environment where they could work as they pleased, ultimately giving them more control of their working environment:

> *"I had the belief that grad school was more to your pace. It has definitely lived up to that expectations 'cause it's your project. You can manage the day as you see fit."—Franklin (first year graduate student)*

While these assumptions are not inherently bad, they set the student up to be disenchanted when the graduate experience is not what they considered to be ideal. Instances of "Ideal Academia" assumptions were more likely to be accompanied by an acknowledgment of error and resulting disappointment.

3. *Expectation: Structured Work*

Some of the participants expected graduate school to be structured, in that they thought it would resemble their undergraduate experiences and/or it would be very directed. Angela discussed this resemblance to undergrad, saying:

> *"So, you'd see that it was stressful but never really seemed extraordinary. It just seems a little bit more like a continuation of undergrad, but with more research focus."—Angela (post-graduation)*

Similarly, Eric believed grad school would be very course heavy, like the typical structure of undergraduate studies, saying:

> *"Well, for one, I thought it was gonna be more classes, which our program doesn't really emphasize classes a lot."—Eric (post-graduation)*

Amy emphasized her expectation that she would be guided through her work more, stating:

> *"I guess I also thought that I would know what I was doing, or someone would tell me what I should be doing. I never expected the extent to which I have no idea what I'm doing like 95% of the time."—Amy (fifth year graduate student)*

**Attitudes towards Expectations**

To add insight to this data, we also characterized the interview excerpts that discussed expectations under one of four categories, deemed "expectation attitudes:" Correct and Positive, Correct and Negative, Incorrect and Positive, and Incorrect and Negative. From the interviews, we determined whether their expectations of graduate school were proven correct or incorrect. It is important to note that these labels *do not* define what is "right" about the expectation (e.g., the expectation of graduate school being coursework heavy, for example, which is generally not reflective of doctoral engineering culture, was not labeled as an "incorrect" belief unless the participant reflected on the expectation and noted that, in their experience, this was not the case.) Through interviewing the participants, we also gathered information as to whether their experiences, which validated or invalidated their expectations, were positive or negative, as determined by analysis of the participant's attitude and phrasing when discussing their experiences. If a participant expected graduate school to be a certain way, the expectation was proven false through experience, and they were unhappy with this, then their experience was categorized as incorrect and negative, for example.

From the data, we observed that graduate students who were late in their graduate career (5th year and above) were more likely to have incorrect and negative expectation attitudes. In total, these late-career students noted incorrect and negative expectation attitudes 11 times throughout their interviews as opposed to the 1 time for early stage and 3 times for mid stage graduate students. Table 1 shows the distribution of instances of attitudes towards expectations among our sample.

*Table 1: Distribution of instances of attitudes towards expectations by gender and academic level. Numbers in each category may not sum to equal the number of participants because participants may have had multiple expectations and resulting experiences.*

|  | Correct and Negative | Correct and Positive | Incorrect and Negative | Incorrect and Positive |
|---|---|---|---|---|
| Male | 2 | 5 | 6 | 6 |
| Female | 3 | 2 | 10 | 4 |
|  |  |  |  |  |
| Early Career and Master's | 1 | 2 | 1 | 4 |
| Mid Career | 3 | 4 | 3 | 3 |
| Late Career | 0 | 1 | 11 | 0 |
| Recently Graduated | 1 | 0 | 1 | 3 |

**Attitudes towards Attrition**

The other overarching category, thoughts on leaving, was used to categorize why participants were thinking about leaving or chose to stay. There were four themes within this category: Academic, Jealousy or Discontent, Persevering, and Considering Leaving. The number of instances are outlined in Table 2. Deciding to stay or leave a program is a complex decision-making process, so many participants voiced ideas that fell into multiple categories.

*Table 2: Distribution of instances attitudes towards attrition by gender and academic level.*

| | Academic | Jealousy or Discontent | Persevering | Considering Leaving | |
|---|---|---|---|---|---|
| | | | | Seriously | Never |
| Male | 4 | 8 | 2 | 2 | 12 |
| Female | 3 | 6 | 11 | 2 | 4 |
| | | | | | |
| Early Career and Master's | 4 | 0 | 1 | 0 | 5 |
| Mid Career | 3 | 7 | 5 | 0 | 5 |
| Late Career | 0 | 4 | 5 | 4 | 3 |
| Recently Graduated | 0 | 3 | 2 | 0 | 3 |

### 1. *Academic Rationales for Attrition*

Some participants were thinking about leaving their graduate programs because of something related to academics. This meant their course-load was too difficult, their grades were suffering, or they were overwhelmed with the amount of work they had to do for school. Katrina explained that she left her graduate program because the classes were becoming too difficult and her grades had suffered, saying:

> *"I found out through calculating out my grades that I wasn't going to have the GPA necessary to continue in the PhD program."—Katrina (third year graduate student)*

Kenneth spoke about his fleeting thoughts on leaving his program, mentioning that the intensity with which he considered leaving was positively correlated to how overwhelmed he was with his workload:

> *"There was finals week spring semester, I was like, "Oh, man, I'm leaving for sure." And then I talked to my girlfriend, my parents, my advisor about it and now, I'm like, "Oh, yeah, I want a PhD again." So, it all depends on the workload that week or the workload that day, just where I'm at."—Kenneth (second year graduate student)*

Simone also expressed similar feelings, saying:

> *So, I think that those feelings really came to me when I was half-dead, studying for coursework and trying to do the research and preparing for meetings or conferences, etcetera."—Simone (second year graduate student)*

Early and mid-stage graduate students were the only students cite academics as a reason to consider leaving their graduate program, likely due to the fact that most engineering graduate programs focus coursework in the first two years of PhD programs.

### 2. *Jealousy or Discontent with Circumstances*

Some of the participants envied others' situations, whether it be another lab's environment or their non-student friends' greater financial success or seemingly less stressful situations. Noah, for example, mentioned his fleeting desire to easily afford housing near his graduate school with a "real" job, stating:

> *"Every once in a while, a thought crosses my mind of, "Oh, I could be making enough money to afford rent around here."—Noah (third year graduate student)*

While Amy had friends telling her the pros of life outside of graduate school and she questioned whether she should stay if things were so much better outside school:

> *"Also, my best friend in the program just recently left after her fourth year here. And so that was like, "Huh, you can do that, that looks awesome I think." And then one of my other good friends left after her fifth year and we've stayed in touch, and she's always telling me how much better life is like not in grad school."—Amy (fifth year graduate student)*

Participants also thought about leaving their graduate programs because they were being driven away, either by their advisor or the pressure to perform. Nadia, for example, sometimes felt overwhelmed with the work she was doing:

> *"...there's definitely been moments where I'm like, "I can't do this. It's too hard. It's too fast-paced. I'm spread too thin. There's too many projects." –Nadia (third year graduate student)*

The stress induced by their current situations was enough to cause these students to look elsewhere for relief, whether it be other labs or outside the program.

### 3. *Attitudes on Perseverance*

Persevering through graduate school was another common theme. Participants who spoke about this usually mentioned their desire to leave their graduate program, but said they were too far into their research or their studies to commit to leaving. They would often rather stick it through since they felt they were so close to the end. Nadia describes this idea of pushing through, saying:

> *"So, there's definitely been some days, some rougher days, where I considered leaving or mastering out, but I'm so close. I don't wanna leave half done. So, I've always stuck around."—Nadia (third year graduate student)*

Michael discussed not realizing how difficult graduate school was until it was seemingly too late in the degree to quit, from their point of view:

*"By the time I woke up from the boiling water I had been in that had been slowly turning up over the last couple of years, by that point, I was pretty far in, and at that point, there was no going anywhere. And so, it was just a matter of pushing forward."—Michael (fifth year graduate student)*

Persevering through any thoughts on leaving their graduate program was more common in mid to late stage graduate students (10 mentions) and more commonly voiced by females (11 mentions) than males (2 mentions).

### 4. *Attitudes on Considering Leaving*

There were some participants who were seriously considering whether they would leave their program. These participants made it clear that, unlike many of the participants thinking about leaving because of academics, they considered leaving multiple times throughout the semester. Amy, for example, explained how she thought about it at least once a month:

*"I did get my masters and was like, "Well, I can leave now if I want." That was sort of a relief… but I've definitely after my prelims considered several times like, "Hey, I've proven that I can do it so I could get a job where I know what I'm doing." Like that would be wonderful. And so I think... I think I actually go through the process of, "Huh, maybe I should quit," like once a month. And it's not idle, it's very serious." —Amy (fifth year graduate student)*

The participants who mentioned serious consideration for leaving their program were all late-stage graduate students.

However, there were also participants who never considered leaving their graduate programs. Some of these participants were adamant about their desire to stay, like Omar:

*"No. No. I've had my ups and downs, but I'm very happy with the lab I chose and I'm very happy with the university I chose, yeah."—Omar (second year graduate student)*

While others had never considered leaving because nothing negative had happened in their graduate career as of yet, like Sebastian who said:

*"Yeah I don't think, if there have been thoughts, they haven't been super serious. So I guess I'm just waiting for the really bad thing to happen, that makes me really consider quitting. But, yeah, nothing's happened that's bad so far."—Sebastian (fourth year graduate student)*

Participants from this study represented a wide variety of opinions about departing from graduate school. There were some at each level that had never considered leaving their PhD program, but in general, male participants were more likely than female participants to express that they had never considered leaving.

**Discussion and Implications**

From the interviews, we saw that a common expectation for graduate school was the idea of an ideal academic setting. This preconception sets students up to be disappointed with the realities of

graduate school that inevitably fall short of that ideal. This is exemplified with the occurrences of this theme in interviews being linked to sentiments of incorrect assumptions and negative experiences resulting from the theme. Both the ideal academia preconception and "incorrect and negative" expectation attitude appeared frequently in interviews where the participant also seriously considered leaving their program. This supports aspects of the Met Expectations Hypothesis that links unmet expectations in a job with higher rates of dissatisfaction and turnover in employees [19]. Regarding socialization, students who come into graduate school with incorrect expectations may have a more difficult time adjusting to life as a graduate student. In any of the common preconceptions, the student may have a fundamental misunderstanding of what it means to be a graduate student. A student may be expecting a poor quality of life and, therefore, may never seek out opportunities to socialize or do something they enjoy because they believe they are supposed to be miserable. From the results of Borrego et al. [28], we can see that a main motivator for incoming engineering graduate students is their own self-efficacy. While these students have faith in their abilities, when their expectations are not aligned with reality, they may not be as prepared as they believe. Experiences which counter the ideal academia and structured work preconceptions may be jarring to the student and leave them feeling disappointed or unprepared. This could lead to further issues later in time as discontentment mounts, contributing to the many, interconnected issues that culminate in attrition, as proposed by the GrAD model [16].

Interesting to note, regardless of expectation type, male participants more often had positive resulting experiences compared to females and females more often had negative resulting experiences. This could be a result of the lower female to male ratio in engineering graduate programs and advisors should be aware that their female students may be having more negative experiences compared to their male counterparts. Advisors of graduate students should also be aware of the common expectations incoming graduate students may have and work to address them early on in their program. A conversation about the student's expectations for life as a graduate student may reveal fallacies that could leave the student dissatisfied with their experience if not corrected. Each school, program, and research group are different, such that no one set of expectations will be correct for every student. Likely, elements from each expectation type will be relevant, while other aspects are exaggerated or completely incorrect. Conversations early on in a graduate student's career could address any misconceptions, establish realistic expectations, and reduce dissatisfaction and consideration of leaving. We also expect that the themes of our findings could be good talking points in graduate seminars, onboarding, or in conversations with prospective graduate students.

We also posit that there are numerous implications for recruiting future generations of graduate students, and accurately reflecting both the joys and trials of graduate school. While research experiences for undergraduate students often are the primary way that undergraduate students become immersed in expectations for graduate school, these experiences may not prepare them for the lived reality of being in graduate programs, including issues of well-being and mental health that graduate students face today. Only by destigmatizing reflective conversation on the nature of expectations and well-being in graduate school can we accurately message life in an academic career to future students.

Further, faculty should be aware of the culture and unspoken expectations about graduate and faculty life that they put on their graduate students. While there is no doubt that an academic career takes dedication, there should be equal conversations of life balance, caring for mental health, and engaging in affirming outside activities to help one become a better researcher. These aspects of a sustainable faculty life should be communicated with graduate students throughout a graduate program and put into practice by faculty as well.

**Conclusion**

We interviewed 35 engineering graduate students and categorized their expectations for graduate school and their thoughts on leaving their program. We found that the preconceptions students had about life as a graduate student centered around expecting poor quality of life, an ideal academic setting, or structured work. While some may seem positive or negative on the surface, all three have elements that likely do not align with reality. Poor experiences relating to incorrect expectations are linked to the student seriously considering leaving the program later on, supporting the met expectation hypothesis. Advisors and mentors of graduate students should work to address any incorrect expectations early in a student's career, potentially reducing the likelihood of attrition.

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