Abstract
Purpose – This study aims to explore different themes related to impostor phenomenon, as experienced by graduate students and postdocs in science, technology, engineering and mathematics (STEM) fields.
Design/methodology/approach – Open-ended survey responses from 120 US-based participants from 40 states and Washington, D.C., describing an occasion when they felt like an impostor, were analyzed thematically.
Findings – Following content analysis, three themes emerged: occurrence, attribution and identity. While impostor-like feelings were experienced as early as high school or college, the majority experienced it during PhD application, on being admitted to a PhD program and throughout PhD training. The people experiencing impostor phenomenon attributed their achievements and success to others (other’s name, prestige, or connections, other’s mistake, other’s lies or misrepresentation, or other’s kindness) or self (self-inadequacy, pretense, luck or self-doubt) rather than their own hard work or ability. Gender-based and race/ethnicity-based identity also shaped the experiences of the impostor phenomenon.
Research limitations/implications – Open-ended survey responses varied in length and level of detail. Responses provided a one-time snapshot of a memory related to impostor-feelings that stood out, not indicating if the feeling persisted or evolved with time. The findings are not generalizable over a larger population.
Originality/value – This study identified multiple themes related to the impostor phenomenon not investigated before, enriching existing research while also providing methodological rigor for the development of follow-up studies.
Keywords Impostor phenomenon, Open-ended survey question, STEM graduate program
Paper type Research paper

Introduction
Ongoing efforts for better inclusion and improved diversity in science, technology, engineering and mathematics (STEM) include interventions at the high school, college and graduate levels to attract more students through early, targeted engagement (Dabney et al., 2017; Hazari et al., 2017; Maltese et al., 2014; Tai et al., 2006). However, there is sparse research on how to support capable individuals once they enter STEM fields, specifically for those who experience the impostor phenomenon.

The definition of the term “impostor phenomenon” has evolved since Clance and Imes (1978) first coined the term, describing it as an “internal experience of intellectual phoniness” among high-achievers. Clance (1985) further explained that it impacted the psychological...
well-being of those unable to easily accept, enjoy or internalize their success; gauge their competence realistically; or recognize their strengths and accept their deficits because of incorrect, self-defeating perceptions of inadequacy, self-doubt and anxiety.

Hellman and Caselman (2004, p. 161) cited Harvey and Katz’s (1985) definition of the impostor phenomenon as “a psychological pattern rooted in intense, concealed feelings of fraudulence when faced with achievement tasks.” The core feelings relate to the belief of fooling others, the constant fear of being found out or exposed hence, and the inability to own one’s success to ability, hard work, and intelligence (Harvey and Katz, 1985). Kolligian and Sternberg (1991) also added to the idea of intellectual incompetence, phoniness, and unjustified fear because of perceived fraudulence (as opposed to real fraudulence), leading to self-criticism and self-inflicted achievement pressures. More recently, the definition has been broadened to include social behaviors of displaying a façade to hide weaknesses (de Vries, 2005).

Overall, these definitions and their variations point to an all-encompassing psychological experience manifesting as the fear of success or failure and being found out (Neureiter and Traut-Mattausch, 2016), self-perceived fraudulence, turning down career advancement opportunities, high anxiety (Fraenza, 2016; Thompson et al., 1998; Thompson et al., 2000), depression (McGregor et al., 2008), mental health issues (Cokley et al., 2017), lower self-esteem (Sonnak and Towell, 2001), low self-efficacy (Blondeau and Awad, 2016), self-doubt (Langford and Clance, 1993), procrastination, perfectionism (Fraenza, 2016) and other self-handicapping behaviors (Ferrari and Thompson, 2006).

The term “impostor syndrome” is sometimes used in popular media. However, Clance (1985), who developed the Clance Impostor Phenomenon Scale and first coined the term, suggests that researchers use “impostor phenomenon” and not “impostor syndrome” as the term “syndrome” refers to an official medical diagnosis [personal communication]. Although first identified among women (Clance and Imes, 1978), the impostor phenomenon has been investigated across genders (Cokley et al., 2015; Burt et al., 2017) and underrepresented minorities such as US-born Blacks (Ewing et al., 1996; Austin et al., 2009) and foreign-born Blacks (Burt et al., 2017). Despite its implications in hindering career progression, existing literature on the impostor phenomenon in STEM is sparse.

**Theoretical framework**

This research study was shaped by Tinto’s (1993) interactionalist theory and integration model (Tinto, 1975) that describes student integration in both formal and informal environments at an institution. Tinto’s focus on undergraduate attrition is particularly relevant. While Tinto (1975) identified assimilation or integration in an undergraduate program as key to success and persistence in college, the current study examines impostor phenomenon using a similar lens, but in a more specialized and complex context of graduate school and academia in general, where high-achieving students sometimes cannot fully assimilate and integrate and continue to feel like impostors. Participant narratives provide insights into how despite their successful enrollment in competitive graduate programs, many are not able to develop a sense of belonging, as examined by Burt et al. (2017). While socialization theory is broadly used to understand PhD attrition because of lack of integration (Golde, 2000, 2005), this study aims to identify aspects of graduate training and socialization experiences that might be particularly problematic for students who are vulnerable to feeling like impostors.
Impostor phenomenon prior to graduate school

The literature on the early occurrence of the impostor phenomenon addresses the experiences of adolescents in high school. Hellman and Caselman (2004) first tested the psychometric properties of the Harvey Impostor Phenomenon Scale (Harvey, 1982) using a sample of 136 high school students. Caselman et al. (2006) found gender differences in how the phenomenon correlated with support from parents, teachers and classmates.

More studies examine the impostor phenomenon among college students, in fields like psychology (King and Cooley, 1995; Thompson et al., 1998; Thompson et al., 2000; Ferrari and Thompson, 2006), medicine, dentistry, nursing and pharmacy (Henning et al., 1998; Villwock et al., 2016; Qureshi et al., 2017). Some of these studies examined correlation between impostor phenomenon, family achievement orientation, grade point average and time spent in academic work (King and Cooley, 1995), perfectionism (Thompson et al., 1998; Thompson et al., 2000), neuroticism and other personality traits like extroversion (Ross et al., 2001).

Fewer survey studies have examined the impostor phenomenon specifically among science and engineering college students (French et al., 2008; September et al., 2001; Blondeau and Awad, 2016). French et al., 2008 examined psychometric properties of the Clance Imposter Phenomenon Scale (n = 1271 engineering students from a large US university), showing satisfactory internal consistency reliability. September et al. (2001) (n = 379 Canadian college students including those in science and engineering) found that those with higher impostor phenomenon have lower self-acceptance. Additionally, Blondeau and Awad (2016) examined 120 undergraduates in the College of Natural Sciences and the School of Engineering (including majors in computer science, biochemistry and mechanical engineering predominantly) from one US public university. They found that the effect of self-efficacy, interest and the impostor phenomenon varied across genders on the future intention of pursuing a career in a STEM field.

Impostor phenomenon in graduate school

Doctoral training is a complex, time-intensive process where novice students integrate into a field, learn to work independently and creatively, develop scientific skills, undergo psychosocial transformation and train to become independent knowledge producers (Lovitts, 2005; Etzkowitz et al., 2000). Those who feel like impostors may be susceptible to struggling through their training, despite their competence.

The literature on how PhD students experience and internalize the impostor phenomenon is limited. At least three studies have examined the relationship between the impostor phenomenon among graduate students, self-handicapping behaviors, paternal overprotectiveness, lack of care (Want and Kleitman, 2006; Li et al., 2014) and childhood parentification (Castro et al., 2004). While some research on the role of the family climate exists, the role of graduate school climate in understanding the impostor phenomenon is not well-documented.

Traditional graduate students experience higher impostor phenomenon than online graduate students, the phenomenon being significantly and positively correlated with anxiety, perfectionism and program type (traditional or online), as shown in a cross-sectional survey with 220 participants (Fraenza, 2016). Traits such as anxious attachment, narcissistic expectations and self-promoted, exaggerated entitlement were significant predictors of the impostor phenomenon because of lower self-worth, as experienced by 170 female psychology graduate students at one US university (Gibson-Beverly and Schwartz, 2008). The impostor phenomenon is negatively correlated with research self-efficacy,
making it a psychological barrier (Jöstl et al., 2015). Those who feel like impostors also experience inadequacy and lack of academic preparedness (Craddock et al., 2011).

There is some evidence that female graduate students are more likely to experience the impostor phenomenon. For example, Jöstl et al. (2015) surveyed 631 Austrian doctoral students (389 female; 21.9 per cent in the natural sciences) of which, female PhD students experienced higher impostor phenomenon. In another autoethnographic study with two female doctoral students (Cope-Watson and Betts, 2010), systemic pressures of academia and the fear of not knowing how to interact in academic settings caused challenges in teaching and professional development and reluctance to seek career development opportunities such as grant writing, chiefly because of the insecurities of being a woman in academia.

The impostor phenomenon particularly increased during the first semester of graduate school, heightened by minority racial identity and high family expectations leading to perfectionism (Craddock et al., 2011). However, Ewing et al. (1996) found that the impostor phenomenon was not related to racial identity but strongly correlated with academic self-concept among 103 Black graduate students of unspecified fields.

**Impostor phenomenon among science, technology, engineering and mathematics graduate students**

Fewer studies have examined the impostor phenomenon in STEM graduate programs, although this phenomenon is experienced by graduate students across many fields such as nursing (Aubeeluck et al., 2016), engineering (Burt et al., 2017) and astronomy/astrophysics (Ivie and Ephraim, 2009). An Austrian study (n = 631 doctoral students; 21.9 per cent in natural sciences) reported that one-third of the sample experienced moderate to strong impostor phenomenon that negatively impacted research self-efficacy, especially for women (Jöstl et al., 2008).

Impostor phenomenon contributed to stress, performance anxiety, loss of confidence, burnout, emotional instability and lack of belonging for nine foreign-born Black male graduate students because of their racial/ethnic underrepresentation in engineering (Burt et al., 2017). The impostor phenomenon brought a lack of belonging not only in the classrooms, department and graduate school, but also in the larger engineering field and Black community (Burt et al., 2017).

A longitudinal study of US astronomy and astrophysics graduate students (N = 1,143; 40 per cent women) also found that women are more likely than men to experience the impostor phenomenon, again characterized by lack of belonging in the field because of the perception of lack of true ability (Ivie and Ephraim, 2009). Those who perceived being mentored also felt more welcome in the field and had the positive perception that they can be successful researchers, making them less likely to experience the impostor phenomenon; however, those who stayed longer in graduate school were less likely to feel mentored and more likely to experience the impostor phenomenon (Ivie and Ephraim, 2009).

**Limitations of current research**

A major limitation of current literature is that participants from diverse and often unrelated fields are lumped together, not acknowledging that experiences of impostor phenomenon could vary by field. For those studies that focus on the impostor phenomenon in specific fields, research on STEM graduate students is sparse and more focused on correlational studies. Qualitative studies are limited by a smaller sample, although providing rich description of their data (Burt et al., 2017). The current literature does not inform us about the prevalence and manifestations of the impostor phenomenon or how early it can
potentially occur in life, especially for those in STEM fields. Building this knowledge will help understand why the impostor phenomenon occurs and how it can be strategically managed, if not overcome. For this, a deeper examination of a range of experiences related to the impostor phenomenon in STEM is warranted. To understand a broader range of experiences, newer methodological approaches not implemented before could potentially uncover underexplored, but relevant themes.

**Research method**

Following IRB approval, eligible participants (those currently in a STEM field in the US as graduate student, postdoc, faculty, or working in the industry) completed a 10-min online survey (Phase 1). All survey-takers were eligible to participate in a 45-min semi-structured, one-on-one, telephone interview (Creswell et al., 2003) if they indicated in the survey that they chose to do so (Phase 2).

Members of Association for Faculty Women at Washington State University were contacted through an advertisement email, sharing a link to the study website with information about the study and the link to the survey. Interested individuals were not only encouraged to participate, but also share the study widely with graduate students and colleagues by email, social media (e.g. Facebook and Twitter), or through word of mouth (e.g. in their classes). This method of snowball sampling can effectively identify new potentially eligible participants with the help of current participants (Sadler et al., 2010). So that snowball sampling does not lead to sampling from a similar pool of participants from the same university, geographic location or field, current participants were explicitly requested to share the study broadly across the USA. Business cards with study information were also distributed to the attendees of the following conferences in 2018: Conference on Understanding Interventions that Broaden Participation in Science Careers and the National Association for Research in Science Teaching. There were no financial incentives to participate.

**Framework for methodology**

The study was named “Understanding the Impostor Phenomenon” study, and the welcome page of the online survey indicated that this study is being conducted to understand why and how individuals experience the impostor phenomenon where accomplished and successful people are unable to believe in their accomplishments or abilities and constantly fear being exposed or feeling like a fraud (Clance and Imes, 1978). No other working definition of the term was provided prior to answering the open-ended questions. The welcome page had contact information of the principal investigator/author if participants had questions.

The 10-min survey included demographic questions (e.g. sex, race or ethnicity, age, field, department and university name, current position and parental education), 34 Likert-scaled items from two previously validated measures of the impostor phenomenon (Clance, 1985; Harvey, 1982) and two optional, open-ended items allowing free-text responses. The first item asked participants to describe, in 50-100 words, an instance when they felt like an impostor. The second item asked them to describe an academic, personal or professional achievement. Despite the word limit guideline, no word limit was set while programming the online survey so that participants could write as much as they wanted. Those who agreed to be interviewed in the survey, if eligible (determined from the open-ended survey responses), were invited to interview at a later date as per mutual availability of both the participant and the author.
This article specifically examines the responses of the first free-text survey item where participants described an instance of feeling like an impostor. Although the qualitative analysis of free-text responses is a common data analysis technique in educational research (Andrews et al., 2011; Wiggins et al., 2017), there are concerns about this being a rigorous way of conducting qualitative research, especially if used as the only source of data collection (LaDonna et al., 2018; Tracy, 2010). However, for a topic as sparsely studied as the impostor phenomenon in STEM, analyzing free-text responses first could provide a variety of themes from a large sample that would help design interview questions in Phase 2. To the author’s knowledge, this technique of using open-ended survey responses to collect initial data for in-depth interviews in the future has not been conducted to understand the impostor phenomenon before.

Participant demography compared to national science, technology, engineering and mathematics graduate programs

Women earned only 31 per cent of doctoral degrees in science and engineering fields in 2015, as compared to 40 per cent master’s degree and 41 per cent bachelor’s degree level (National Science Foundation Science and Engineering Indicators report, 2018). The number of women in science and engineering occupations (28.4 per cent overall) included 26.4 per cent computer and mathematical scientists, 27.8 per cent physical scientists and 14.5 per cent engineers in 2015. Similarly, in 2015, science and engineering doctoral degrees earned included 20,000 or 66.9 per cent White, as compared to 4,000 underrepresented minority students (1,855 or 3.4 per cent Black, 2,019 or 4.6 per cent Hispanic/Latino, and 137 American Indian/Alaska Native) (National Science Foundation, 2018).

This study analyzed open-ended survey responses for the first item from graduate students and postdocs in STEM who described an instance when they felt like an impostor either before or during graduate school. Those who did not respond to this item or described instances that occurred after graduate school were not included in the analysis. Of the 165 graduate students and postdocs overall, 120 responses were eligible for analysis using the criteria mentioned above. Of them, there were 87 PhD students and 33 postdocs. Further, 101 (84.17 per cent) participants identified as female and 93 (77.5 per cent) White. The study sample had an overrepresentation of women and Whites when compared to the national average, although members from all races/ethnicities were represented. A detailed breakdown of participants based on gender, race/ethnicity, age range and current position is provided in Table I.

Participants represented 81 universities and research centers across 40 US states and Washington D.C. More specifically, there were 36 participants from the Northeast, 30 from Midwestern US, 24 participants from Southern US and 30 participants from Western US.

Participants represented 64 different specialties overall from science, engineering, and mathematics/statistics. Some of the representative specialties in science and engineering include: Astronomy, Biochemistry, Cell Biology, Chemical and Biological Engineering, Chemistry, Earth and Environment, Electrical and Computer Engineering, Geological Sciences, Materials Engineering, Mechanical Engineering, Pharmacy and Physics.

Data analysis

The 120 responses varied in length from one line to as many as 240 words. The author, along with two graduate students previously trained to analyze open-ended survey responses, read each response together to analyze the content and came up with a consensus on the appropriate theme that fit the response. Where the coders did not agree, a discussion
was held until a consensus was reached. The themes were then compiled using analytic induction (Glaser and Strauss, 2017; Miles and Huberman, 1994; Pope et al., 2000). Data analysis occurred over three weeks. Attention was paid to how researcher worldview could influence data analysis and to any disconfirming evidence not consistent with emergent themes (Antin et al., 2015). Each theme and sub-theme were illustrated with representative quotes, with bracketed text clarifying participant responses. Participants’ field and current position were also included.

Results
The following three themes developed from data analysis: occurrence, attribution and identity.

Theme one: occurrence
Of those who shared instances of feeling like an impostor, some described events as early as in high school (n = 6) or undergraduate training (n = 24), while others (n = 90) shared relevant experiences during PhD application, on being admitted to a PhD program, and throughout PhD training.

High school: A troubling aspect of the findings was the revelation that some participants felt like impostors as early as high school. For example, a third-year Chemistry student, on winning the best show in science fair during high school, thought:

The judges are just impressed that I am so feminine and yet so knowledgeable in molecular biology, the bar for me is just lower because I am feminine and I’ve surpassed their low bar, I wouldn’t pass the higher bar set for my male classmates.

Another first-year Animal Science student, on being selected for a science camp during high school, thought that she was not qualified enough and was “selected due to a lack of applicants from my state.” Other examples are provided in Table II.

College: The impostor phenomenon persisted during college and intensified particularly after an achievement such as winning a scholarship or competition or receiving an award for undergraduate research. For example, a fifth-year Biochemistry student, on winning a

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Table I.
Number of study participants by gender, race/ethnicity, age range and current position

<table>
<thead>
<tr>
<th>Current position</th>
<th>PhD student N = 87</th>
<th>Postdoctoral trainee N = 33</th>
<th>Total N = 120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Female</td>
<td>73</td>
<td>28</td>
<td>101</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Asian</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Black</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Hispanic</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>White</td>
<td>67</td>
<td>26</td>
<td>93</td>
</tr>
<tr>
<td>Age range</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>58</td>
<td>8</td>
<td>66</td>
</tr>
<tr>
<td>30-39</td>
<td>25</td>
<td>19</td>
<td>44</td>
</tr>
<tr>
<td>40-49</td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
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scholarship, “questioned their [the judges’] judgement for choosing me over other “smarter” applicants” while a second-year Pharmacy student felt like an impostor on winning an academic writing contest because “I used a silly paper I wrote for a Biochemistry undergrad course to enter a departmental writing contest.” A sixth-year Neuroscience student, on winning “a prestigious fellowship at the NIH summer internship program” and being among the top ten from hundreds of applicants, “never felt that I deserved the honor.” Similarly, on receiving an undergraduate research award, a second-year Physics student “doubted that I was correctly selected because I did very little original research and wrote the entire document in just a couple days.” Another fourth-year Environmental Sciences student, on being accepted to a Research Experiences for Undergraduates program, thought that it was a mistake and added:

When I was selected as outstanding student in multiple undergraduate departments, I thought it was a joke. I disbelieve people when they tell me I’m good at what I do.

Some even doubted their inclusion into research groups. A second-year Neuroscience student “felt like they added me to the follow-up project because I had presented [at Howard Hughes], but that they didn’t really want me on the project.” Students felt like impostors when they perceived lacking certain skills (e.g. coding). A first-year Biomedical Engineering student said, “I felt like I was the only one who didn’t know how to code or do anything technically advanced, and I questioned whether I had the right skills and if I was creative enough to excel in engineering.”

<table>
<thead>
<tr>
<th>Theme 1: Occurrence</th>
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<tbody>
<tr>
<td>High school</td>
<td>In high school, I applied to the [name of national award] and was one of the 25 selected out of 20,000 from all parts of the country. I have always seen myself as the token privileged person to show that the project is meritocratic and not need-based (first-year Civil and Environmental Engineering student) As a senior in high school, I applied for an apprenticeship program that would pay me to work in a biology lab for one year. I still feel extremely lucky that this worked out. Many times, I feel like I didn’t really do enough to be accepted into that program and so didn’t necessarily do enough to get to where I am today (second-year Microbiology student)</td>
</tr>
<tr>
<td>College</td>
<td>When I was accepted to [higher ranked university] for undergraduate studies, I was convinced it was a mistake and was only accepted because I was of Mexican origin. I chose not to attend and accepted admission at [lower ranked college] (second-year Earth Sciences student) As a first-generation college student, I was shocked when I was accepted to [name of Ivy League institution] for undergraduate studies, and suffered from significant self-doubt while there, to the extent that I did not challenge myself in my coursework, and continually avoided academic involvement in study groups, lab groups, and extra-help tutoring sessions. I was afraid of asking stupid questions or seeming unqualified to be there (fifth-year Neuroscience student)</td>
</tr>
<tr>
<td>Graduate school</td>
<td>I just feel like I don’t deserve to be in graduate school, especially when I am struggling with class work or asked to take on a new task. I’m just good at parroting and getting enough information from other classmates or the professor to get through the tests, but I shouldn’t be getting As or Bs on them (first-year Biomedical Engineering student) When I first entered graduate school, I certainly felt like I didn’t belong. I had essentially been grandfathered into the program, and my academic background was relatively weak. Many of my entering colleagues were all high-achieving students, some with Ivy League research backgrounds. I felt very inadequate and felt that my adviser had made a mistake by giving me a chance (third-year Psychology student) I have been contacted to review a submission for an academic journal that I hope to someday publish in. I have only had three articles published and completed one year of my PhD. I don’t think I have the expertise to review others’ work (first-year Natural Resources student)</td>
</tr>
</tbody>
</table>
The impostor phenomenon persisted even after completing college. After finishing her degree and topping the class, a third-year Industrial Engineering student felt “disbelief and I felt as though they had made a mistake or I had tricked someone. I did not feel qualified to work on planes or other aerospace systems.”

Graduate school: The impostor phenomenon was particularly prevalent in graduate school for the rest of the participants \( n = 90 \), during PhD application, after getting admission into a PhD program, or for the rest of PhD training.

Experiencing the impostor phenomenon affected the number and the quality of PhD programs one applied to. For example, more than one participant echoed the concerns of a second-year Engineering student:

I did not anticipate going to graduate school at all because graduate school is for smart people, not me. I didn’t even consider going to top schools since I’m not smart like that even though I had a 4.0 in all my engineering coursework.

A second-year Pharmacy student did not apply to as many schools “because I didn’t think I deserve it.” Similarly, a fifth-year Earth and Environment Science student “didn’t think I would be good enough to get into top [graduate] schools, so I didn’t apply everywhere I could have.”

Many students were surprised on being accepted to a PhD program, attributing their acceptance to good luck, error or the assumption that other students must have turned down the offer. A second-year Neuroscience student feared being admitted to a PhD program “because of the recommendation letter of a former research advisor, and that I must have fooled everyone during the interview and throughout the coursework.”

Similarly, a first-year Agricultural and Biological Engineering student was surprised that “My advisors wanted me to work on some of their grant-funded research. The thought of someone valuing my brain power was odd to me.” A second-year Pharmacy student “question[ed] my acceptance into pharmacy school because I’m waiting for myself to finally start failing,” while a first-year Earth and Environmental Sciences student felt that her PhD admittance was a “sign that I deserved to be a PhD student, against what I had believed thus far.” A fourth-year Molecular Microbiology and Immunology student shared:

I don’t think I was prepared for it [graduate school]. I feel like I somehow tricked my PhD mentor into accepting me and now they’re just trying to mitigate the damage.

The impostor phenomenon particularly intensified and many felt surprised, underserving, and underprepared to start a PhD after admission for reasons such as lacking prior research experience, switching fields after college, low grade point average or standardized test scores such as the Graduate Record Examination, moving from a smaller liberal arts college to a larger university, going to an expensive school while not being from a wealthy family, being amid “big names in the field and much better prepared fellow students,” and being waitlisted. For example, a third-year Astronomy student:

[... repeated]ly wondered if I’m as good as my classmates, even though I know rationally that the stats for astronomy grad admissions mean those on the waitlist are just as qualified as those admitted right away. I still wonder this, even three and a half years in.

The above example also shows that the impostor phenomenon persisted over time. Similarly, a fifth-year Biology student shared, “When I first got into grad school, it took me a couple of years to really feel like they hadn’t made a huge mistake in letting me in.”

Starting a PhD was difficult and evoked impostor-like feelings for many. A fifth-year Mechanical Engineering student shared:
After arriving in graduate school, I felt that I wasn’t a good researcher and that the PhD program had made a mistake. I was enjoying my experiences, but I felt it was only a matter of time before I would be deemed inadequate.

Similarly, a fourth-year Earth Sciences student from a top institution in the country spent most of his first year “convinced they’d made a mistake, often staring out the window instead of working because I was so struck by intellectual vertigo.” Others shared specific transition challenges during the first year because of low confidence, lacking a sense of belonging, and self-doubt. An older, Hispanic female student shared her nervousness of starting graduate school in her forties with young men who “talked big and sounded intelligent” that made her question if she got admitted “because of my cultural background rather than my ability. I was so stressed and worried they’d figure out I’m stupid.” Another first-year Civil and Environmental Engineering student struggled with depression and wondered “if I should have done something else between college and graduate school to prepare myself better. Or if I should take a leave from graduate school and find a job.”

**Theme two: attribution**

In all, 46 participants attributed their impostor feelings to “others,” that included other’s name, prestige or connections, other’s mistake, other’s lies or misrepresentation or other’s kindness that was perceived as a contributing factor rather than hard work or ability.

As examples of other’s name, prestige or connections, many who won competitive funding or fellowships, even at the federal level, felt that this was because their PhD advisor is famous or politically connected. A fourth-year Biomedical Sciences student who was awarded an NIH training fellowship, attributed it to “the prestige of my PI [principal investigator].” Similarly, a PhD scholar in Biology felt that she did not deserve her Fulbright award and “got it based not on the project itself but rather who my advisor was and the letter he wrote me.” A Neuroscience postdoc shared getting her position “because my former boss [in PhD] is famous.” Looking back, a Biology postdoc shared similar feelings about receiving a PhD fellowship where “it was her [the advisor’s] compelling research area that was the reason for this award and not my qualifications.” In describing other’s connections, a Marine Science postdoc feared being hired “because my postdoc advisor likes my graduate advisor” and that her postdoc advisor “knows nothing about me or my work and I worry that once he knows more, he won’t be impressed.” A first-year Earth and Environment student felt like she was selected to the PhD program because “my past advisor knew my current advisor,” and a second-year Civil Engineering student felt she was admitted because “my [Master’s] professor is a friend of [my PhD] professor.” Participants continued to attribute their achievements to others throughout their PhD, such as after passing the comprehensive exams because “I was convinced my comps committee liked my boss, so I would have passed no matter what.” A second-year Conservation Biology student felt being recruited “completely on a positive impression, and not real skill” because her name was referred to by someone close to her advisor and felt that she did not deserve her research assistant position because “I don’t believe I have the intelligence or statistical skills to have gotten into this position on my own merit.”

While describing other’s mistakes, a fourth-year Biological Sciences student compared her achievements to that of her PhD peers and felt that “my advisor somehow chose incorrectly, or maybe she just needed to have another student for her tenure application and maybe I was the only one that applied.” A postdoc in Biology feared that “my graduate advisor never realized that parts of my dissertation were shoddy or incomplete or wrong, and therefore gives me better recommendations than she ought to.” A Biomedical Sciences postdoc who won the best poster award at a national conference as a graduate student,
“honestly thought that they called my name as a mistake and that they were going to pull me to the side and tell me it was a mistake.” A Biology postdoc, on getting an A+ in a graduate course, was “firmly convinced that the professor made a mistake and had confused me with another student.”

A second-year Biology student felt that her PhD admittance was because she had somehow deceived the admission committee who made a mistake and “would change their minds after they met me.” A first-year Biology student felt:

I was only accepted based on the false recollections of my former mentors; that in reality, I do not belong in this position and that I’m faking my ability to continue on this track until my supervisors realize they’ve made a mistake.

Describing examples of other’s lies or misrepresentation, a first-year Microbiology student could not believe that he was accepted to five renowned schools and he “was convinced my references lied. I still refuse to accept that schools might actually want me for a student.” In a letter of recommendation, a Chemistry postdoc felt that “that my [PhD] advisor must have lied by omission if he thought I should continue in a research position and recommended me for it.”

Participants held many incorrect beliefs about their achievements and attributed their success to their PhD advisor’s or dissertation committee’s kindness. On completing a PhD in Mathematics and Statistics, a participant felt like an impostor because “I had a weak dissertation and that I only passed my defense because my committee was being kind and knew I had a job lined up at a lower-tier university.” On winning a competitive scholarship, a second-year Mechanical Engineering student felt that “the people who wrote my recommendation letters embellished and exaggerated.”

Fewer (16 participants) attributed their impostor experiences to the self, such as self-inadequacy, pretense, luck or self-doubt. In describing self-inadequacy, a second-year Ecology student felt inadequate because “I don’t think I have such a solid background as to run a project, I don’t feel as prepared as the rest of my colleagues.” A Neuroscience postdoc thought:

[…] my [PhD] work was not good at all. I was always feeling and still do that I am a disappointment for my boss. I always feel inferior to other people in my lab.

A fourth-year Chemical and Biomolecular Engineering student shared:

I feel like an impostor because of a general sense that I don’t know enough about my field or topic or don’t ask enough good questions to be a real scientist.

In describing pretense, a Biochemistry and Cell Biology postdoc felt like an impostor in her PhD lab meetings:

Not remembering all the details of a new method, and then going completely blank after imagining how they find out that I don’t remember such stuff and still stand there and pretend to be a scientist.

Luck was another factor attributed by a third-year Biology student who said that “I always felt I won the award [in graduate school] because people personally like me, rather than being a good scientist, and that I lucked into performing well.” A fourth-year Biological Sciences student shared, “The wrongness of my PhD position has lessened over time, but I still feel like I got here on luck and not work.” A first-year Molecular Neurobiology student reflected, “from always being a good student all my life, I started feeling like I reached here by pure luck and one day people will find out the real me that is not so smart as I come across.” A first-year Computer Science student felt that she was admitted not based on her
previous achievement, but "because of luck in who I knew and the people who vouched for me" and felt underprepared because of having "considerably fewer skills and abilities than some of my classmates."

In describing self-doubt, a third-year Immunology and Molecular Microbiology student expressed doubts while applying for a competitive fellowship. "Throughout the application process, I questioned whether I had enough grit to stay dedicated to completing the application." Another Plant and Microbial Biology postdoc added:

My time of greatest self-doubt was as a graduate student. Then and sometimes even now I doubt whether I deserved to pass my final PhD defense and be awarded my degree.

Theme three: identity
In total, 24 participants discussed identity in terms of gender or race/ethnicity. Some female PhD students had difficulty internalizing their achievements (such as winning graduate research fellowships and awards) because of their gender. On winning a competitive, federally-funded graduate research fellowship, a third-year Chemistry student felt that "they only chose me because they want to show [gender] diversity." Similarly, a third-year Engineering student, on receiving a competitive conference travel award, thought that it was "for bringing [gender] diversity to the conference and I assumed it must have been a fluke." A fourth-year Microbiology student who was awarded a travel grant felt that she was not the best candidate, but "by choosing me they were able to check a [gender] diversity checkbox."

Such views of favored selection based on gender were shared by other women, especially in male-majority fields such as physics, astronomy, and engineering, where achievements were based on "my gender and not on my actual abilities," as described by a fourth-year Aerospace Engineering student. A seventh-year Human Genetics student, on being invited to speak at an international conference, felt that "I was being part of an effort to have young researchers but mostly, female talks." Another fourth-year Biomedical Engineering student believed receiving a competitive training fellowship from her institution through the NIH because "my institution wants to encourage women in STEM."

Such instances were sometimes based on disparaging comments from other male peers or colleagues. For example, a third-year Engineering student, on receiving a professional "Young Engineer of the Year" award, was told by her male colleague that "it must not have been a very large applicant pool," a comment that plagued her and heightened her impostor-like feelings. An Entomology postdoc who was admitted to many top universities for a PhD was:

Told by my male professor that I didn’t belong in science even though I was doing well in my classes and rotation lab. I believed him and went to a less prestigious school.

Racial/ethnic diversity was also discussed. A first-year Ecology and Evolutionary Biology student who won a competitive fellowship for excellence and equity in research felt undeserving and wondered if "I am Hispanic ‘enough’, or if I am the scholar and researcher that they think I am." A fifth-year Hispanic Physics student believed that he was admitted to the PhD program only because he was also offered funding through a graduate diversity fellowship. Another sixth-year Mathematics student, on being considered for a research internship interview, learned how the company emphasized on "hiring women and underrepresented minorities and immediately began to worry that I was being considered largely because I am a double minority."
Discussion and conclusion

This study identified three main domains related to the impostor phenomenon in graduate education in STEM: occurrence, attribution and identity. In total, 30 participants described feeling like an impostor as early as during high school or college. However, 90 participants experienced the impostor phenomenon while applying to, on being admitted to, and throughout PhD training. Consistent with Burt et al. (2017) research, study participants described a lack of belonging in graduate school as well as in science, although their experiences were not always racialized. To foster belonging, early interventions and support at the beginning of, and throughout graduate school could help students identify early and manage their impostor-like feelings. Graduate student orientation at the school or departmental level could initiate conversations on the impostor phenomenon and point to support systems available for students.

In all, 46 participants attributed their impostor phenomenon to others (other’s name, prestige, or connections, other’s mistake, other’s lies or misrepresentation or other’s kindness) and 16 to self (self-inadequacy, pretense, luck or self-doubt). While many undervalued their potential, as consistent with the definition of the impostor phenomenon (Clance, 1985; Harvey and Katz, 1985; Kolligian and Sternberg, 1991; de Vries, 2005), they also overestimated other’s abilities. Future research could identify an understudied area of how much of the impostor phenomenon is attributed to internal factors versus explicit cues from the environment, and the interplay between the two.

In total, 24 participants also discussed how their gender or racial/ethnic identity contributed to the impostor phenomenon. Given the overrepresentation of women and their underrepresentation in many STEM fields, it was surprising that the gender theme did not emerge more frequently. Nevertheless, this theme elucidates how personal and professional identities can shape the impostor phenomenon.

In the future, research could explore the role of impostor phenomenon in mental health issues among graduate students, especially women and minorities in STEM. In doctoral training, the transition from the dependent phase (course taking, building content knowledge) to independency (producing original research) requires integrating in a research environment, developing research skills, being autonomous, and often, navigating loosely defined benchmarks of success (Lovitts, 2005; Etzkowitz et al., 2000). Graduate training is lengthy, culturally complex and involves transition to research independency which might be challenging for those who already feel like impostors. Such training requires significant psychosocial transformation that students are not always prepared to handle (Lovitts, 2001, 2005; Etzkowitz et al., 2000), especially in many STEM fields that require practical training in laboratories (Goldman and Marshall, 2002). It was concerning that participants in this study reported impostor-like experiences even before, but especially from the start of graduate school. Many felt underprepared to transition to graduate school. Concerted efforts to help students recognize, understand and manage the impostor phenomenon would be crucial, necessitating more and early opportunities for professional development.

Specifically, there is a great deal of concern in the USA regarding mental health issues, stress, anxiety, and suicide in graduate populations (Eisenberg et al., 2007; Hyun et al., 2006). The impostor phenomenon has been examined in the context of mental health outcomes among undergraduate students more than graduate students. Such experiences put students at a risk to experiencing depression (Chrisman et al., 1995) and mental health issues (Henning et al., 1998; Sonnak and Towell, 2001). Young college-going adults in the USA (including women, especially African American women) who experience the impostor phenomenon are also more vulnerable to mental health issues because of gender and racial discrimination (Bernard et al., 2017). Cokley et al. (2013) found impostor-feelings to be a
stronger predictor of mental health issues among college students from ethnic minority backgrounds compared to mental health stress. Similarly, among British college students, lower levels of self-esteem and poorer mental health were significant predictors of the impostor phenomenon (Sonnak and Towell, 2001). It would be imperative to extend this research to examine mental health outcomes among graduate students in STEM who experience frequent or higher levels of the impostor phenomenon.

Graduate students often heavily rely on a strong network of support system consisting of advisers, mentors, peers and family to complete their doctoral training (Kong et al., 2013). Thus, it would be important to examine the role of others in perpetuating the impostor phenomenon in future research. In this study, the role of others was evident only while describing how gender identity added to the impostor feelings among women who received disparaging comments from peers and colleagues. Recent research has described the value of forming closed-mentorship networks or triads among undergraduates, new or advanced graduate students/postdocs and faculty members to provide advice, psychosocial support and mentorship (Aikens et al., 2016, 2017; Chakraverty et al., 2018). As a follow-up to this research, interviews in Phase 2 of the larger study focus on the role of peers, mentors and advisers in perpetuating the impostor phenomenon. Understanding the role of doctoral student networks in their research identity development (Pifer and Baker, 2016; Baker and Pifer, 2014; Baker et al., 2014; Baker and Pifer, 2011; McAlpine and Amundsen, 2011; McAlpine and Amundsen, 2009) would elucidate how others working closely with graduate students in STEM can contribute to their experiences of the impostor phenomenon.

A limitation of using open-ended survey questions was that the responses varied in length and level of detail. Responses provided a one-time snapshot of an impostor-experience that stood out the most. However, it could not be assessed if the impostor phenomenon persisted and how did it evolve over time. To address these limitations, the second phase of the study focus on in-depth interviews. In addition, the findings are not generalizable over a larger population.

As impostor phenomenon in STEM is a relatively understudied area, these open-ended survey responses were a source of rich information that not only generated relevant themes not studied before, but also provided methodological rigor for planning the second-phase of the study in at least four ways. One, methodologically, by leveraging on a survey that was faster to complete than an interview, a high sample size was achieved for the pool of diverse participants from a wide demography (field, geographic region, age range, etc.) who could be potentially interviewed. Two, open-ended survey responses provided a quick and efficient screening mechanism for contacting potentially eligible interview participants (for example, by not contacting those who left the item blank or indicated that they never felt like impostors). Those who feel like impostors are successful and skilled, yet feel underserving or incompetent (Craddock et al., 2011; Schubert, 2013). Thus, the second open-ended question where participants described an achievement helped ensure that the participants were clearly very accomplished although they felt like impostors. Three, the responses provided a breadth of topics to be used as probes to expand upon during in-depth interviews. Four, the responses informed the development of interview questions through the emergent themes in this article, especially helping develop questions that were not considered a priori. This study not only provided an understanding of the occurrence and attribution of the impostor phenomenon, but also raised additional questions that would be investigated in the next phase. Prior studies on the impostor phenomenon have mostly employed surveys using closed Likert-scale items (that do not probe deeply into student experiences) or interview techniques. However, collecting open-ended, descriptive survey data, as in this study, is
innovative, time- and resource-efficient, and will aid in the further development of this research.

Future research could longitudinally investigate how impostor phenomenon develops and evolves over time. Other than implementing the next phase where this research examines, in more detail, why and how the impostor phenomenon develops in graduate school, this research also strives to create safe spaces for honest conversations about impostor-experiences from students and professionals. Such conversations in formal or informal settings could help students develop a sense of belonging and facilitate their assimilation in their respective fields and programs. Study findings build on Tinto’s (1975, 1993) academic interaction and social integration theory, showing the complexity of graduate school experiences where student networks play an important role in their training, assimilation and gradual cultural integration (Kong et al., 2013; Aikens et al., 2016, 2017), both academically and psychosocially (Golde, 2000, 2005). This can reduce isolation, develop a sense of community and address the impostor phenomenon, especially among the vulnerable groups such as women and minorities.

The strength of this study lies in the richness of data collected through a demographically diverse sample. While prior studies have focused on one or few institutions, the diversity of this sample indicates that the impostor phenomenon is pervasive across fields, institutions, age groups, genders and life stages, with instances as early as high school. Despite inherent limitations, this study furthers the literature by expanding its current ambit, while also opening up additional unanswered questions for future investigation, such as the role of advisers, mentors and social networks in either perpetuating or addressing the impostor phenomenon.

References


Further reading


Tinto, V. (1987), Leaving College: Rethinking the Causes and Cures of Student Attrition, University of Chicago Press, Chicago, IL.

About the author

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