

Supporting Engineering Graduate Students in Professional Identity Cultivation through Disciplinary Stewardship

Megan Frary

Megan Frary is an Associate Professor in the Micron School of Materials Science and Engineering (MSMSE). She also serves as the Associate Director for Undergraduate Programs in the MSMSE. Since 2013, Dr. Frary has also been the Coordinator for Graduate TA Support in the Center for Teaching and Learning; in this role, she works with graduate students to better prepare them for their current and future teaching work. Dr. Frary has been recognized for her teaching work with both the 2008 Bradley Staughton Award from ASM International and the 2016 ASEE Pacific Northwest Section Outstanding Teaching Award. Her current research is related to (1) how teaching experiences help graduate students develop their professional identities and (2) how to evaluate teaching effectiveness.

Donna C. Llewellyn (Executive Director)

Paul Simmonds

Julianne A. Wenner (Associate Professor)

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Introduction and Problem

Historically, graduate education's goal was to prepare future academics/scholars, and it has thus focused on the creation and conservation of disciplinary knowledge [1], [2]. However, the reality today is that most engineering graduate students (GSs) go on to non-academic careers [3], [4]. As educators, it should be our aim to equip GSs for success, regardless of career aspirations, and to be more thoughtful about what 'success' in a particular field means. Boyer states that,

...graduate study must be broadened, encompassing not only research, but integration, application, and teaching, too. It is this vision that will assure, we believe, a new generation of scholars, one that is more intellectually vibrant and more responsive to society's shifting needs [5, pp. 73–74].

It is therefore essential that we shift paradigms in graduate education and focus our efforts on preparing a *new type of scholar* – one with a strong professional identity – rather than preparing a person for a specific type of career. We argue that what has been largely missing from graduate education is a focus on supporting the cultivation of a professional identity [6].

In line with the cultivation of a “new generation” of scholars, the Carnegie Initiative on the Doctorate asserts that graduate education should produce *stewards of the discipline*: people who “creatively generate new knowledge, critically conserve valuable and useful ideas, and responsibly transform those understandings through writing, teaching, and application” [2, p. 5]. We see the *transformation* element of graduate education, defined as “encompass[ing] teaching in the broadest sense of the word,” [2, p. 11] as being a key component to developing professional identity. The ability to connect ideas across disciplines and apply abstract knowledge to real problems and scenarios—as one does when teaching others—is a necessity for the development of a strong professional identity [7].

Consequently, it is the integration of knowledge transformation (teaching) into graduate STEM education to support the creation of a strong professional identity that led us to create the Graduate Identity Formation through Teaching (GIFT) project. Through five semesters of implementation, we have asked the following research questions:

1. In what ways does participation in GIFT appear to promote the development of STEM GS professional identity?
2. In what ways does participation in GIFT appear to support feelings of disciplinary stewardship in STEM GSs?

We see the findings of this study as informative to graduate educators across disciplines as

we consider how to support engineering GSs in terms of their current educational activities and their future careers.

Related Literature

Attrition is one of the biggest issues facing graduate education. In some fields, the rate of attrition is as high as 40% [8], with a disproportionate impact on underrepresented minorities (URMs; [9]). Beyond issues of attrition, however, is the content of a STEM graduate degree program itself. The National Science Foundation (NSF; [10]) has called for professional development (PD) offerings for GSs, but research shows that when PD happens, it is chiefly targeted towards those who wish to pursue academic careers [3]. Given the fact that many STEM GSs will not become academics [4] as well as the fact that 39% of GSs change their career goals after entering graduate school [11], such narrowly-targeted PD programs are unlikely to benefit the majority of GSs.

As GSs progress in their education, they create their professional identity. We use Bragg's notion of professional identity as the "internalization of the norms of the profession into the individual's self-image...[and] the acquisition of the specific competence in knowledge and skills, autonomy of judgment, and responsibility and commitment of the profession" [12, p. 11]. Because GSs are pursuing a specialized degree in a particular discipline, professional identity and disciplinary identity (e.g., a mechanical engineering identity) are likely to be inextricably linked [13]. Components of a disciplinary identity are competences (knowledge), performances (ways of being/doing in a particular discipline), and recognition (internal/external; [14]). Taken together, professional identity formation within a discipline (i.e., internal and external recognition as an engineer) requires one not only to learn the competences and performances related to that discipline, but also why the discipline is important, and how to use one's expertise for the greater good. The importance of professional identity formation cannot be overstated, as failure to do so can limit graduates' career choices and success [15].

Golde's [2] notion of disciplinary stewardship makes clear that understanding a field is meaningless without connecting and applying this knowledge in society. To those ends, graduate education should allow students to consider how their disciplinary knowledge can solve real-world problems [16] and serve a purpose that is larger than one's career trajectory [2]. Development of disciplinary stewardship can hence be a form of socialization into a particular field. Socialization, a process wherein GSs take on a discipline's values, knowledge, and skills [7], is vital to professional identity creation [17]. During socialization, GSs acquire both general and specialized knowledge, become invested in their area of specialization, and adopt roles associated with their profession or discipline. It is this third component that is central to professional identity development as it allows others to witness the performance and validate the identity [18]. Therefore, GSs deepen their commitment to their profession (professional identity) as they apply their knowledge to real world problems, and communicate their knowledge across disciplinary boundaries (disciplinary stewardship), to reinforce their knowledge and skills, as well as to create opportunities for recognition by others as a disciplinary expert.

Intervention

GIFT has been implemented in its current form for five semesters, beginning in Spring 2019. In GIFT, GSs are supported by the project faculty and a one-credit course to construct adult-level, inquiry-based, 30-minute lessons based on specific topics related to elementary (K-6) Next Generation Science Standards (NGSS; [19]). The GSs meet with elementary teacher candidates (TCs) to teach the lesson and serve as disciplinary experts on the topic. The TCs subsequently turn this knowledge into 15-minute mini-lessons for elementary students. To bring GIFT full circle, the GSs observe the TCs teaching the lesson and reflect on the entire experience (see [20] for more details on this intervention).

Methods & Design

We undertook a pragmatic ethnographic approach to this research, as we sought to better understand shared patterns of values, behaviors, and beliefs of the GSs in GIFT collaboration [21]. As such, we utilized both qualitative and quantitative data to better understand GSs' experiences.

Setting

This study took place at Boise State University which has approximately 24,000 students, with roughly 3,000 of those being graduate students. 73% of the student population is white, with the next largest racial/ethnic group identified as Hispanic (13%). The university offers 14 STEM master's degree programs and eight of the 13 doctoral degree programs offered are in STEM areas of study.

Participants

Over the course of five semesters, we recruited 31 STEM graduate students from several different departments, with a focus on biology, physics, engineering, and geology, as these best align with the broad areas of content in the NGSS [19]. Twenty-eight of these GSs consented to our GIFT study. A summary of the demographic characteristics of these participants can be found in Table 1.

Table 1

Graduate Identity Formation through Teaching Participants

Self-Identified Gender	Race/Ethnicity	First Generation College Student	Graduate Field	Graduate Program Type	Future Career Plans
	White = 20		Materials Science = 12		
	Black = 2		Biology = 7		Undecided = 12
Male = 13	Hispanic = 2	No = 22	Geosciences = 4	Masters = 15	Industry = 9
Female = 15	Asian = 3	Yes = 6	Mathematics = 1	Doctorate = 13	Gov't Agency = 4
	Two or more Races = 1		Chemistry = 1		Academia = 3
			Mechanical Engineering = 3		

Data Collection

Course assignments. We used two assignments within the one-credit course to collect data: (1) a reflection on their meetings with the TCs; (2) an end-of-semester reflection on how they had changed professionally during GIFT as well as any benefits and potential impacts of GIFT on their future career. All participants completed each assignment.

Surveys. Participants were given a pre-/post-survey with 20 five-point Likert-scale questions centered on statements connected to professional identity and disciplinary stewardship (e.g., “To what extent do you feel you can communicate big ideas in your field to those outside of your field?” or “To what extent do you feel committed to your engineering/science field?” etc.). Twenty GSs completed both the pre-survey and post-survey. Note that survey participation waned during the COVID-19 pandemic.

Interviews. Each GS was interviewed for approximately half an hour at the conclusion of the semester. The semi-structured interview [22] focused on themes of their experiences in GIFT, the one-credit course, and their interactions with the TCs. Twenty-five GSs participated in the interview. Each interview was recorded and transcribed verbatim.

Data Analysis

To analyze the quantitative data, we compared the scores on the pre/post-survey and used one-tailed *t*-tests to ascertain significance. To analyze the qualitative data, we sought to answer each research question individually, although as can be seen, there is much overlap between the cultivation of professional identity and disciplinary stewardship. Data was coded in a constant comparative manner [23] to uncover the nuances within each research question.

Findings

GIFT and STEM GS Professional Identity

One with a strong professional identity in STEM might be able to say, “I see myself and am recognized as a member of the (mechanical engineering, geology, etc.) professional community and acknowledge my knowledge and skills in the field.” The quantitative results indicated that GIFT was indeed able to support GSs in cultivating this feeling. After participating in GIFT, GSs felt better able to identify and share core ideas and beliefs from their field and felt more committed to their chosen field of study.

When asked “How confident are you that you can articulate the core values and ethical responsibilities of your field?” (with 1= not confident at all; 5= absolutely confident), the average response increased from 3.59 in the pre-survey to 4.29 on the post-survey ($P=0.003$). To this point, GS6 stated,

GIFT has made me consider how I will represent my discipline as a STEM professional. This includes making ethical research decisions, not ignoring injustices within my field,

and communicating ideas from my field to others. It's made me think a lot more about how important it is to be able to share my findings with a larger audience. It's also made me think about my responsibility as a STEM professional to teach and mentor students within my field.

Similarly, GS9 shared that he felt an increased responsibility to share his work with the public, “especially those that aren't in a STEM or related field, as they are the ones who may be impacted by my work.”

Moreover, when asked their level of agreement with the statement, “I feel committed to my science/engineering field,” (1= strongly disagree; 5= strongly agree), the average response increased from 4.06 in the pre-survey to 4.65 on the post-survey ($P=0.020$). For some GSs, this increased feeling of commitment appeared to come from realizing that their graduate degrees would allow them to have broader interests and career possibilities, thus they did not need to choose between their current field and something else. For example, GS2 stated, “GIFT has made me realize that being a PhD student does not mean I must become a researcher to put my expertise to use. I can still utilize science for the public good by other means.” Likewise, GS17 declared that his career plans changed, but he will stay within his field; he now wants to be a “science communicator” to the general public “especially in the geoscience field,” underscoring his commitment to the field. Still others stated that their commitment to and identification with their field increased because they were able to acknowledge their expertise. GS3 commented, “GIFT helped me feel more like an expert in my field by having to interact with others and share the knowledge I have. As such, I am more confident as an engineer now than before starting GIFT.” GS5 simply stated that after participating in GIFT, “I am not totally sure I want to be ‘a researcher’ or ‘a professor’, but my feeling that I am a scientist has been reinforced.”

GIFT and Disciplinary Stewardship

As a result of their GIFT experiences, many of the GSs noted that disciplinary stewardship could become a vehicle to increase a feeling of belonging in their field. For example, GS16 stated, “I see opportunities to further integrate with my disciplinary community through outreach and teaching.” Through the GIFT activities, GS9 felt that he had been equipped with teaching and mentoring skills that would help him to “play a more active role in my research group by mentoring undergraduates and...help them to feel more engaged with the community than I felt when I first started.”

When asked “How confident are you that you can identify ways in which your field can contribute to society?” (1= not confident at all; 5= absolutely confident), the average response increased from 3.88 in the pre-survey to 4.41 on the post-survey ($P=0.007$). Further, when asked “How confident are you that you could communicate big ideas in your field to those outside of your field?” – a question very tightly-tied to the transformation aspect of disciplinary stewardship as well as to the implementation of the GIFT – the average response increased from 3.32 in the pre-survey to 3.94 in the post-survey ($P<0.001$).

Given that the GIFT involved GSs working with teacher candidates, many GSs focused

on outreach in terms of giving back to the field of education in particular. Some GSs considered ways to support teachers, such as GS6: “GIFT really showed me how valuable it is for K-8 educators to have access to content area experts and makes me wonder if there would be a way for me to do that more permanently.” GS2 had not previously realized how little science content elementary teachers are often prepared with, leading him to share, “I figured that science teachers were taking like 50% teaching classes, 50% science classes. I see that isn't the case...It makes me want to be this sort of resource for the [TCs] in the future.” GS19 summed up her feelings by stating, “Getting people while they're young, to understand the importance of [science] is probably more effective than trying to reach them later...I definitely think that responsibility falls on us [scientists] to help support...teachers.”

Other GSs considered how to adapt materials or reach out to students directly. GS5, a botanist, shared that, “I have started to consider the resource that herbaria represent and how we could use herbarium materials as a teaching/educational resource, which would be beneficial to the field.” Similarly, GS8 wanted to share soil science and ecosystem ecology with students while GS13 and GS20 considered how they could create simple experiments and outreach programs for local schools. Finally, GS16 acknowledged the fact that she is a female scientist and wanted to serve as a role model in the community, since she did not experience that as a student.”

Conclusions

In this study we sought to investigate the ways in which GIFT supported the cultivation of a professional identity and feelings of disciplinary stewardship in STEM GSs. As can be seen in the findings, these two constructs appear to go hand in hand, as the GSs in this study found that the transformation aspect of disciplinary stewardship supported them in feeling more committed to (and belonging to) their field, as well as allowed them to consider their field's core values and responsibilities to the public. In turn, the GSs saw more ways to integrate with their field via disciplinary stewardship and sharing their passion for their fields with others. That is, becoming disciplinary stewards (via GIFT) supported the GSs in this study to deepen their professional identity, and vice versa. Given the need to better support engineering GSs in obtaining a graduate education that will serve them in a variety of careers as well as to support them in feeling as though they belong and can persist in their chosen field, we see GIFT as being a promising model to be implemented in conjunction with engineering graduate programs. Importantly, this is a model that is transferable to any engineering and/or STEM graduate program, does not place a huge burden on GSs in terms of coursework, and does not require grant money or university appropriations to run successfully.

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