

Wenner, J.A., Simmonds, P., Frary, M., & Llewellyn, D. (2022, January). *Those who don't teach....should learn*. Roundtable presented at the Association for Science Teacher Education Conference, Greenville, SC.

Those Who Don't Teach...Should Learn

“Those who can't do, teach.” This hurtful adage continues to be common, implying that those who are teachers are somehow lesser, not quite as smart, or could not make it in a ‘better’ profession. Unable to hack it as a chemist? Become a chemistry teacher. Can't make a living as an artist? Become an art teacher. However, one could argue that this adage – and the damage it wreaks – persists because the general public does not fully understand what teachers *do* and the expertise involved in teaching well. Jan Sidebotham, a 30-year veteran of the classroom, wrote in a 2015 *Washington Post* article that people generally believe teachers:

- Teach five classes or so.
- Prepare lessons.
- Create assessments such as quizzes, tests and other assignments.
- Grade assessments.
- Take long vacations. (para. 1)

Sidebotham goes on to explain what each of these five items truly entails (including the fact that the ‘long vacations’ do not actually happen), and then proceeds to list quite a few more duties. Similarly, Tess Plona, a first-year teacher in 2019 notes that, “Since becoming a teacher, I have heard many false assumptions from people outside of the field of education. Knowing how hard we work...it is disheartening to hear the harsh judgments that many people so frequently make about teachers” (para. 1). In addition to setting the record straight on other teaching-related duties, Plona specifically speaks of the pressure related to planning and executing successful lessons and assessments that support all students’ learning.

Although public attitudes towards K-12 education are relatively positive (see Gallup Education questions, 2021), as can be seen, there are fundamental misunderstandings about the knowledge teachers hold, the skills they possess, and the thought and planning required to be an effective teacher. Further, specific to *science* education, the recently-released *Call to Action for Science Education* report (National Academies of Sciences, Engineering & Medicine [NASEM], 2021) calls on *communities* to support K-16 science education via resources, cultivating a diverse workforce, mentorship, and financial investments. In other words, science education will need the public – not just people within the field of education – to meet this call to action.

The question then becomes, how do we, as educators and science teacher educators provide an accurate picture of science education with those outside the field? The assumption being that a better-educated public may be more supportive in a number of spheres as well as see ways in which their fields may connect and collaborate with science education and education more broadly. Therefore, the purpose of this roundtable will to be to discuss the unexpected findings from a project that pairs STEM graduate students (GSs) with elementary teacher candidates (TCs). These findings demonstrate increased awareness of and appreciation for teaching on the part of the GSs. We see these unanticipated findings as something that could

perhaps be expanded into more purposeful collaborations in the future and would like to discuss these possibilities further with others in our field.

Theoretical Framework

This study is framed by the concept of disciplinary stewardship. Golde (2006) notes that a disciplinary steward is one who "...will creatively generate new knowledge, critically conserve valuable and useful ideas, and responsibly transform those understandings through writing, teaching, and application" (p. 5). While there is certainly much overlap between the generation, conservation, and transformation components, we focus on the transformation component within disciplinary stewardship, which encourages students to consider how their disciplinary knowledge can be communicated across disciplinary boundaries (Lawson, 2014), solve real-world problems (O'Meara & Jaeger, 2006), and serve a purpose that is larger than one's career trajectory (Golde, 2006). GSs begin their graduate careers learning more deeply about the knowledge and skills of their field and then contribute to the field via experimentation and new knowledge generation. However, Elkana (2006) argues that one cannot be a professional in the sciences without also being a teacher and one who adds to the public understanding of science. Moreover, Elkana states that professional scientists must be able to communicate science in such a way that it is responsive to social context rather than simply regurgitating explanations.

In our intervention, which will be described next, the notion of disciplinary stewardship is at the heart of our partnership. We constructed an intervention that would allow STEM GSs to communicate knowledge from their field to TCs. However, it seems the TCs served as inadvertent disciplinary stewards as well, sharing the field of education with the GSs.

Intervention

The Graduate Identity Formation through Teaching (GIFT) Project 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; NGSS Lead States, 2013). The GSs meet with the 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 at a local Title I school. To bring GIFT full circle, the GSs observe the TCs teaching the lesson and reflect on the entire experience. For more information on this intervention, see Wenner and Simmonds (2017).

Methods

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 (Creswell & Poth, 2018). As such, we utilized both qualitative and quantitative data to better understand GSs' experiences; this proposal will focus on the qualitative data. Below, we describe our participants and the data collection and analysis methods relevant to this proposal.

Participants

Over the course of five semesters, we have 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. Twenty-eight of these GSs consented to our GIFT study. More details about these participants can be found in Table 1.

Data Collection

Course assignments. We used two assignments within the one-credit course to collect data: (1) a reflection on course activities as well as their meetings with the TCs; (2) an

end-of-semester reflection on how they had changed professionally during GIFTas 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 seven open-ended questions in which they could share their perspectives on personal growth over the semester, their experiences, and the potential impact of GIFT on their career. Twenty-two GSs completed the pre-survey and 21 GSs completed the post-survey. Note that survey completion declined during the COVID-19 pandemic.

Table 1

GIFT Participants

GS Identifier	Semester in GIFT	Self-Identified Gender	Race/Ethnicity	First Generation College Student	Graduate Major	Graduate Program Type	Future Career Plans
GS1	SP19	F	White	N	Materials Science and Engineering	Masters	Industry
GS2	SP19	M	Hispanic	Y	Materials Science and Engineering	Doctorate	Gov't Agency
GS3	SP19	M	White	N	Materials Science and Engineering	Masters	Industry
GS4	SP19	M	White	N	Materials Science and Engineering	Masters	Industry
GS5	FA19	F	White	N	Biology	Masters	Undecided
GS6	FA19	F	White	N	Biomolecular Sciences	Doctorate	Undecided
GS7	FA19	F	White	N	Ecology, Evolution & Behavior	Doctorate	Academia/ Industry
GS8	FA19	F	White	N	Biology	Masters	Undecided
GS9	SP20	M	White	N	Materials Science and Engineering	Doctorate	Gov't Agency
GS10	SP20	M	Two or more	N	Materials Science and Engineering	Masters	Industry
GS11	SP20	M	White	N	Mathematics	Masters	Undecided
GS12	SP20	M	White	N	Mechanical Engineering	Masters	Undecided
GS13	SP20	M	Black/ African American	N	Materials Science and Engineering	Doctorate	Academia
GS14	SP20	F	Asian	N	Chemistry	Masters	Industry
GS15	SP20	M	White	N	Materials Science and Engineering	Doctorate	Gov't Agency
GS16	FA20	F	Hispanic/Two or more races	Y	Geosciences	Masters	Undecided
GS17	FA20	M	White	N	Geosciences	Masters	Gov't Agency
GS18	FA20	M	White	Y	Geosciences	Doctorate	Undecided
GS19	FA20	F	White	N	Geosciences	Doctorate	Academia
GS20	FA20	F	White	N	Biomolecular Sciences	Doctorate	Undecided
GS21	FA20	F	Black/ African American	Y	Biomolecular Sciences	Doctorate	Academia
GS22	FA20	F	White	N	Biology	Masters	Undecided
GS23	SP21	F	White	N	Mechanical Engineering	Masters	Industry
GS24	SP21	M	White	Y	Materials Science and Engineering	Masters	Industry
GS25	SP21	M	Asian	N	Materials Science and Engineering	Doctorate	Industry
GS26	SP21	F	White	N	Materials Science and Engineering	Masters	Undecided

GS27	SP21	F	White	N	Materials Science and Engineering	Doctorate	Unknown
GS28	SP21	F	Black/ African American	Y	Biomedical Engineering	Doctorate	Unknown

Interviews. Each GS was interviewed for approximately one hour at the conclusion of the semester. The semi-structured interview (Roulston, 2010) 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

We began our analysis for GIFT as a whole using an inductive approach (Saldaña, 2016) to ensure we captured salient themes beyond our original research questions connected to the effectiveness of GIFT (Wenner et al., in review). From this, we noticed a strong – and unexpected – theme around the increased understanding of and appreciation for science education and teachers. This led to a second round of coding in a constant comparative manner (Glaser, 1965) to uncover the nuances in this unexpected theme.

Findings

The findings are organized around four sub-themes. Note that these will be discussed in further detail during the roundtable.

Planning an Effective Lesson is Difficult

The one-credit course all GSs were enrolled in was designed to support the GSs as they taught their science lessons to the TCs, but also for them to gain understanding of broader factors surrounding teaching and learning (e.g., stereotype threat, impostor syndrome, etc.). And while we never expected GSs to fully grasp all that teaching entails or design ‘perfect’ lessons, project participation gave them sufficient insight that they could recognize the thought and planning required to craft an effective lesson. For example, GS1 stated, “Preparation is vital in engaging the students and making the material stick,” while GS9 commented,

Before participating in GIFT, I wasn’t really aware of what went into teaching. I knew teachers didn’t just “wing it”, but there is so much more to teaching than I realized. I am now more aware of how minute details of a lesson or of a class might affect students.

Further, GSs realized that there are many different things teachers must account for when planning a lesson – not simply content. GS12 noted, “Teaching must account for all types of student knowledge and experiences...It is really important to gauge audience knowledge and get assumptions about a topic before getting into the details.” Similarly, GS9 remarked that teachers must “account the student actions and reactions” and that they are “...now much more aware of the effort that must go into [lessons].” GS27 summarized their feelings towards lesson planning by stating, “This experience gave me a lot of respect for the amount of work that goes into making and giving a lesson, especially at the K-8 level where you’re expected to teach a variety of topics.”

Content Expertise is Not the Same as Teaching Expertise

In the same vein, GSs noted that simply because one is a content-area expert, this “does not automatically make me magically good at teaching what I know to another person” (GS3). Similarly, GS13 observed,

The most important fact I've learned is that knowing the concepts is not the same as the ability to educate students...I realize how deeply one needs to think about teaching and the steps that should be taken to prepare students for success.

And GS15 humbly stated,

Just because I'm an 'expert' in a field doesn't necessarily mean that I'm the best person to teach it to others. Teaching effectively is a skill in itself that needs to be learned and explored. I've learned that in order to communicate my knowledge better to the larger community, I need to not only become an expert in my field, but I need to also practice 'teaching' and/or explaining my knowledge in a manner where someone who knows nothing about my discipline can understand.

This was a particularly important realization for GSs who were currently teaching assistants or anticipated taking on that role or the role of an academic. These GSs found that lessons learned from their GIFT collaboration could be applied to other classes/settings.

Seeing Teaching as a Well-Honed Skill

Through GIFT, GSs also observed that teaching requires much more skill and practice than they originally thought. Many GSs commented on the grace with which the TCs were able to implement their lesson with elementary students, and how they were able to take up students' ideas and stay on track. For example, GS8 commented,

The 6th graders made instant logical jumps that I wasn't able to predict. I had a lot of respect for the teachers who are able to 'herd the cats'...Being a teacher means that you're adaptable and can foster student learning in any situation.

GS18 also shared their amazement at the TCs' lesson implementation:

The professionalism and adeptness my [TC] team displayed during their delivery was impressive...Each deviation of attention from the lesson was followed by a smooth recapturing. Wrong statements and misinformation were precisely dealt with. To an extent, interpersonal skills are more important than great content. I have a new respect for K-12 instruction.

Similarly, GS22 observed that, "The way the teacher responds, the words they use, and the prompts they give can be the difference between a successful and unsuccessful learning experience," while GS28 noted that teachers must "...understand a subject at a high level...portray that subject to different grade groups in a way that they can relate to, make it interesting and exciting, and be able to keep that motivation going for forever."

Through both lesson planning and observing the TCs in action, the GSs expressed their overall appreciation for teaching science well:

- GIFT made me realize the difficulties science educators face in incorporating quality scientific education in their classrooms. – GS6

- K-8 educators have so much more influence than I think a lot of people realize, because one exceptionally bad or exceptionally good experience with a teacher can have a long-lasting impact on a student and their future careers...Beyond that, classroom teachers really take on more roles than just traditional educators; they're role models to students, they have to manage a whole classroom of students, and attend to and understand every student's unique situation. They are more important than I think a lot of people assume they are (also educators deserve to be paid more). – GS23
- Beyond teaching content, instructors have a huge responsibility of nurturing the curiosity of the students and teaching them how to be effective learners. This experience made me realize that teaching may be one of the most interdisciplinary fields out there. – GS27

Ways to Give Back

Finally, as a result of their GIFT experiences, many of the GSs noted that they wanted to take up the idea of disciplinary stewardship in a way that would give back to the field of education. 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.” 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. 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. Finally, GS17 shared his dream of creating a geoscience podcast for students and the general public that would “show people that uniting the STEM fields can help make what humans do on Earth more efficient and better for the planet.”

Discussion, Contributions to the Field, and Interest to ASTE

Through GIFT, GSs had the opportunity to plan and teach one lesson, interact with TCs, and see the fruits of their labor as TCs implemented a lesson based on the GSs' content with elementary students. While we had hoped for this to be a mutually beneficial collaboration for GSs and TCs, we were surprised to see how much GIFT supported GSs in their awareness of and appreciation for science teaching. Given the action steps laid out by the *Call to Action for Science Education* report (NASEM, 2021) to elevate the status of science education and establish alliances for STEM opportunity, we might argue that those who do not teach in their career might learn to teach – even for one semester – as this appears to provide more clarity of the complexities involved in effective science teaching. And, it appears that even a brief and simplified stint in teaching may support those outside the field of education in becoming advocates and helpers for science educators (among other benefits; see Authors, forthcoming).

In our roundtable, we hope to have conversations with science teacher educators as well as those who may also teach in content-specific departments (e.g., biology, geology, etc.) to consider how more purposeful interventions may be created in the future with undergraduates as well as graduate students. High-quality K-16 science education is vital, as “Science is an essential tool for solving the greatest problems of our time and understanding the world around us. Scientific thinking and understanding are essential for all people navigating the world, not just for scientists...” (NASEM, 2021, p. 7). If we are able to create a better-educated public regarding science education, we increase the chances of providing the science education opportunities all students deserve.

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