Exploring STEM Teaching Assistants' Self-Efficacy and Its Relation to Approaches to Teaching

Cody R. Smith,[†]* Deepika Menon,[‡] Annette Wierzbicki,[¶] and Jenny M. Dauer[¶]
[†]Department of Kinesiology, Missouri State University, Springfield, MO 65897; [‡]Teaching, Learning & Teacher Education and [¶]School of Natural Resources, University of Nebraska–Lincoln, Lincoln, NE 68503

ABSTRACT

Undergraduate and graduate teaching assistants (TAs) play large roles in introductory undergraduate education despite having little to no teaching experience or professional development (PD). Self-efficacy and teaching approach have each been studied as independent variables that impact teaching performance and student learning in the absence of practiced skill or developed knowledge. This study explored relationships between TAs' teaching approaches and teaching self-efficacy. Self-efficacy was measured using the Graduate Teaching Self-Efficacy Scale (GTA-TSES), and teaching approach was measured using the Approaches to Teaching Inventory (ATI). The following research questions guided the study: What is the relationship between TAs' approaches to teaching and their self-efficacy? How do approaches to teaching and self-efficacy interact to impact the model of TA self-efficacy? Both ATI subscales correlated strongly with the GTA-TSES learning environment subscale and weakly with the instructional strategy subscale. High self-efficacy TAs demonstrated more concern with impacting student learning, which may contribute to a more student-centered teaching approach. Results indicate that TAs with more confidence in their teaching ability may have a more student-centered approach than teacher-centered approach to teaching. Implications include enhancing TA PD with peer mentoring, constructive feedback, and reflection and incorporating learning concerns in the model of TA teacher efficacy.

INTRODUCTION

Undergraduate and graduate teaching assistants (TAs) often play a large role in instructing introductory undergraduate courses, laboratories, and other supplemental learning sections and have high levels of direct contact with undergraduate students (Gardner and Jones, 2011). However, they receive little to no teaching experience or professional development (PD) opportunities that focus on pedagogy before teaching introductory undergraduate courses (Reeves *et al.*, 2018). In the absence of knowledge or practiced skill, self-efficacy, or one's belief in one's own ability, influences one's actions when attempting to succeed at a given task (Bandura, 1977, 1986). Studies that investigated TAs' self-efficacy suggest that teaching experiences enhance self-efficacy (DeChenne *et al.*, 2012), although other variables such as TAs' roles and involvement, amount of teaching responsibility, and PD received also impact self-efficacy (Boman, 2013; Mills and Allen, 2007). Further, TAs' teaching self-efficacy, or their belief in their ability to effectively complete teaching tasks such planning and delivering a lesson or assessment, could influence their teaching performance and thus the quality of their students' educational experiences (Bandura, 1997; Tschannen-Moran *et al.*, 1998).

One's approach to teaching, particularly whether teacher-centered or student-centered, has been reported to affect teaching performance (Nespor, 1987; Trigwell and Prosser, 2004). Teacher-centered teaching is broadly characterized as the teacher at the

Elisabeth Schussler, *Monitoring Editor*
Submitted Jun 16, 2022; Revised Dec 2, 2022; Accepted Dec 7, 2022
CBE Life Sci Educ March 1, 2023 22:ar6
DOI:10.1187/cbe.22-06-0115
*Address correspondence to: Cody R. Smith (codysmith@missouristate.edu).

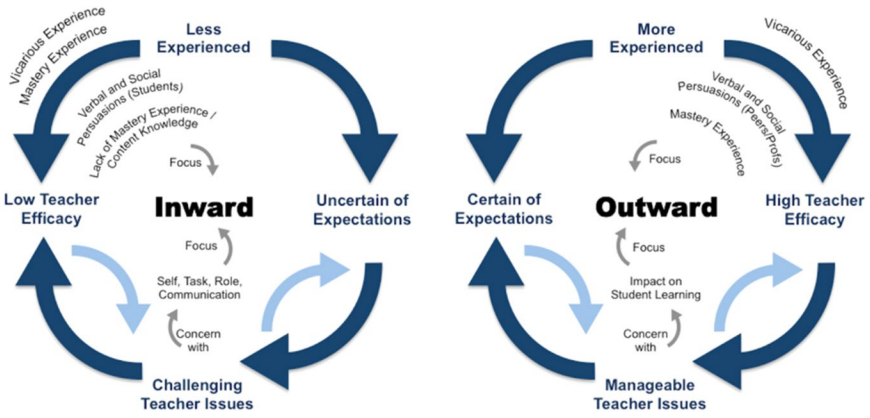

FIGURE 1. Model of TA self-efficacy from Smith and Delgado (2021).

head of the classroom, presenting key ideas to be learned by the students while asking questions and giving corrections, whereas student-centered teaching emphasizes cooperative learning through group discussion and projects, allowing for students to construct their own knowledge with one another (Vygotsky, 1962; Schug, 2003). Student-centered teaching is reported to provide an enhanced active-learning environment for students, giving students agency in the classroom and increasing conceptual understanding by giving them more responsibility for and control over their own learning (Wright, 2011; Freeman *et al.*, 2014; Auerbach and Andrews, 2018). Trigwell and colleagues (1998) reported that student-centered approaches are associated with students demonstrating a deeper understanding of content and that teacher-centered approaches result in more surface-level learning. Self-efficacy and teaching approach are both indicators of whether a TA's focus of concern is limited to their own selves and tasks or has moved outward to their students' learning (Henderson *et al.*, 2011; Smith and Delgado, 2021). Without experience or formal development, TAs assume traditional, teacher-centered approaches, such as what they experienced as students (Hammrich, 2001; Gormally *et al.*, 2016).

THEORETICAL FRAMEWORK AND BACKGROUND LITERATURE

Self-Efficacy and Its Relation to Graduate TAs

Self-efficacy is an influential construct in the field of teacher education (Bandura, 1986; Nespor, 1987). Studies have shown association between self-efficacy and teacher effectiveness (Sehgal *et al.*, 2017), commitment to the profession of teaching (Yost, 2006), classroom management and ability to adapt to reform-based instruction (Klassen and Chiu, 2010), and teaching performance (Klassen and Tze, 2014). Bandura proposed two dimensions of teaching self-efficacy: personal teaching efficacy and outcome expectancy. Personal teaching efficacy refers to individuals' belief in their ability to teach the subject effectively and support learning (Bandura, 1993). Outcome expectancy is the ability to estimate whether teacher actions will lead to desired student outcomes (Bandura, 1993; Deehan, 2017). Both dimensions are interrelated and together impact teacher behavior, motivation, and actions (Bandura, 1986). Teachers develop self-efficacy in many ways through various experiences, which may or may not necessitate firsthand experience. Bandura (1997) proposed four sources of self-efficacy beliefs: mastery experiences (one's own experience succeeding at a task, MEs), vicarious experiences (observing others succeeding at a task, VEs), verbal and social persuasion (receiving affirmation or words of encouragement, VSP), and emotional arousal (emotional and physiological states). These sources all have the potential to impact the development of both dimensions—personal teaching efficacy and outcome expectancy.

Studies on TAs' self-efficacy have yielded mixed results regarding the relationship between classroom experience and self-efficacy. While one may assume that MEs enhance self-efficacy, the study conducted by (Kim (2009) reveals that teaching experience did not correlate with self-efficacy related to student engagement. Other studies found a positive relationship between teaching self-efficacy and teaching experience (DeChenne *et al.*, 2012). It has also been noted that TA PD plays a crucial role in developing self-efficacy; however, the quality and duration of PD are influential factors (DeChenne *et al.*, 2015). Studies also found that TA PD benefited novice TAs more than experienced TAs (Boman, 2013).

Smith and Delgado (2021) developed a model of TA self-efficacy (Figure 1) in an effort to advance the literature on TA PD by framing factors that improve the self-efficacy of TAs and how to shift their focus of concern beyond their own tasks to impacting student learning. The model is based on TA interview data that indicated the main sources of self-efficacy for high and low self-efficacy TAs. These sources were derived from the work of Bandura (1986, 1997) and included the two dimensions of self-efficacy and the four main sources of self-efficacy. The model explains that less-experienced TAs have low self-efficacy because of a lack of both ME and disciplinary content knowledge. These factors influence the TAs' focus inward upon how they are perceived to be performing, which hinders them from focusing on their impact on student learning. Instead, low self-efficacy TAs rely heavily on student feedback, which is not a consistent indicator of quality instruction (Kendall and Schussler, 2012). In contrast, the model describes that more-experienced TAs rely heavily upon ME, VE, and feedback from reliable and experienced peers and professors as sources of higher self-efficacy and a greater outward focus on their students' learning and how they are impacting it. The model links these aspects to previous literature indicating TAs who are more developed in their teaching and perceive teaching issues as manageable tend to have a greater concern for student learning than those who are less developed and view teaching issues as challenging and demonstrate more concern with their own tasks and roles (Nyquist and Sprague, 1998; Cho *et al.*, 2011). Further development of this model is needed to enhance its utility for understanding teacher performance. Learning how teaching approach relates to teaching self-efficacy could further improve the model of TA self-efficacy to inform best practices for TA PD.

Teaching Beliefs and Approaches in Graduate TAs

Teaching beliefs have an impact on an instructor's teaching techniques and instructional decisions they carry out in the classroom (Schoenfeld, 1998). Specifically, how one views the nature of student learning and one's own role as an instructor can affect teaching practice (Keys and Bryan, 2001). Those who believe learning can be constructed from one's own prior knowledge use strategies that build upon students' prior conceptual understanding, while those who assume learning is a result of addressing a knowledge deficit approach learning and instruction from a position of reinforcing information (Hashweh, 1996). Teaching approaches develop over time, and one can progress and regress from a more teacher-centered to a more student-centered approach along one's teaching career (Gormally *et al.*, 2016). TAs are perhaps most susceptible to experiences and information influencing their teaching. Their primary examples of teaching approaches are during their time as students observing their professors' practices. Hammerich (2001) suggests that challenging TAs' existing conceptions of the nature of teaching is imperative to changing their teaching approaches. She proposes that improving TA pedagogical content knowledge (Shulman 1986), or understanding how to best utilize appropriate teaching techniques in a given subject area, is key to influencing teaching conceptions.

It takes practice to overcome long-ingrained teacher-centered approaches and to master inquiry-based teaching. Gormally and colleagues (2016) found that even after learning new inquiry-based techniques, TAs still approached these techniques from teacher-centered perspectives. For example, while leading introductory biology laboratories prepped with inquiry-based teaching strategies, TAs still felt responsible for their students' success and felt compelled to provide the answers rather than allowing students to struggle and find the answers themselves. Their findings suggest that an impediment to shifting to student-centered approaches was the students themselves, who pressured TAs to practice non-inquiry techniques by requesting more teacher-centered feedback. This finding is in agreement with the Smith and Delgado (2021) model, which shows how novice TAs' beliefs and practices are susceptible to student influence, which may not reliably indicate effective instruction.

Research Questions and Rationale

This study sought to improve understanding of how self-efficacy may be leveraged to impact TAs' approaches to teaching. It also sought to further develop the Smith and Delgado (2021) model by exploring how teaching approach relates to teaching self-efficacy and by describing any relationships found between these two variables. This will enhance the model's utility for connecting self-efficacy to teaching performance in order to better inform TA professional development opportunities. Based on the previous model from Smith and Delgado, we predicted that TAs with higher self-efficacy, more experience and an outward focus (focused on students' learning) will demonstrate more student-centered teaching approaches. We used the following questions to guide the study:

1. What is the relationship between TAs' approaches to teaching and their self-efficacy?
2. How do approaches to teaching and self-efficacy interact to impact the model of TA self-efficacy?

METHODS

Research Design, Participants, and Context

This study used a triangulation convergence mixed-methods research design using quantitative and qualitative data to seek answers to the research questions (Creswell, 2014). The triangulation convergence design allows researchers to collect and analyze quantitative and qualitative data and converge the results by comparing and contrasting research findings from the two sets of the data (Creswell and Clark, 2017). Quantitative data included a correlation analysis to determine any relationships between self-efficacy and approach to teaching. Qualitative data were collected in interviews to explore and interpret any relationships found between self-efficacy and teaching approach.

Participants in the study were 18 graduate and undergraduate students who were TAs during the 2019–2020 school year at a large midwestern university. Undergraduate TAs were included with the assumption that, having previously passed the course they were teaching and having no more or less PD than graduate TAs, they possessed similar levels of knowledge and skills as graduate TAs. TAs were recruited by emailing science departments and requesting access to TA contact information, as well as advertising the research opportunity among students in a science literacy course that the authors teach. TAs were offered $30 as incentive to participate in the study. All TAs who responded and consented to participate were included in the study. Table 1 details demographic information for the 18 TAs who participated in this study, including the course they were responsible for as a TA.

The eight TAs who taught Science Literacy Recitation were responsible both for attending lectures that were taught by instructors and for leading a recitation section. During the lecture, they assisted the instructor by facilitating small-group discussions. For the recitation, they were responsible for generating and maintaining a classroom discussion on the topics discussed in class and assisting with small-group research projects throughout the semester. TAs were given general instruction materials to use, but they were also given much liberty to lead the recitation at their own discretion. The four TAs who taught General Genetics were given a course packet with all materials and information to cover during a recitation section. Responsibilities of TAs in General Genetics included presenting long problems related to the topics covered in lecture, leading students through these problems, and answering students' questions related to the problems. The two TAs who taught Fundamentals of Biology led students through supplemental instruction sessions outside lecture time in which students were given the opportunity to go over lecture material in more depth and with more discourse with the TA. The three Insect Identification TAs both lectured and facilitated group activities in their classrooms while being a resource for further discussion regarding the topics covered in the course. The TA who taught Fundamentals of Biology Lab was given laboratory materials to demonstrate to students as a class and then facilitate the students' conducting the experiments on their own. Written laboratory reports were assigned that were graded with feedback by the TA. Participants were not required by the university or their departments to complete any formal PD before being appointed to their positions, and they all stated that they had not voluntarily completed any PD courses or workshops. Institutional Review Board approval was given for this research study.

TABLE 1. Participant demographic information

Pseudonym	Age	Gender	Race/ethnicity	Graduate status	Teaching experience (semesters)	Course
Ivy	24	F	W	Grad	0	Science Literacy
Oakleigh	21	F	W	Undergrad	3	Biology Lab
Bivan	35	M	A	Grad	2	Science Literacy
Hector	25	M	H/L	Grad	2	Science Literacy
Ava	20	F	W	Undergrad	3	Biology
Gretchen	21	F	W	Undergrad	3	General Genetics
Naomi	22	F	A	Undergrad	3	Biology
Jahi	26	M	A	Grad	0	Science Literacy
Valentina	20	F	H/L	Grad	0	Insect Identification
Everett	25	M	W	Grad	6	Insect Identification
Sawyer	22	M	W	Undergrad	3	General Genetics
Amare	28	M	B/AA	Grad	2	Science Literacy
Nick	25	M	W	Grad	5	Science Literacy
Kensley	23	F	W	Undergrad	1	Science Literacy
Daniella	20	F	H/L	Undergrad	1	General Genetics
Elizabeth	22	F	W	Undergrad	4	General Genetics
Ariana	29	F	H/L	Grad	4	Science Literacy
Julietta	26	F	H/L	Grad	4	Insect Identification

Note: F, female, M, male; A, Asian/Asian American; B/AA, Black/African American; H/L, Hispanic/Latinx; W, White.

Data Collection

To document TA self-efficacy and teaching approach, we collected TAs' presemester responses to the Graduate Teaching Assistant Teaching Self-Efficacy Scale (GTA-TSES; DeChenne *et al.*, 2012; Supplemental Appendix A) and the Approaches to Teaching Inventory (ATI; Trigwell and Prosser, 2004; Supplemental Appendix B). Both instruments were previously validated. The GTA-TSES is an 18-item survey that indicates one's confidence in one's ability to complete specific teaching tasks. Responses are given on a five-point Likert scale from 1 (not at all confident) to 5 (very confident). The GTA-TSES measures total teaching self-efficacy and includes two subscales of self-efficacy labeled "learning" (GTA-TSES-L), which focus on more difficult and complex concepts like providing an active and positive learning environment, and "instructional" (GTA-TSES-I), which focuses on instructional activities such as preparing for and teaching class (DeChenne *et al.*, 2012). Reliability of the instrument for this sample was explored using Cronbach's α, and the values show that the internal consistency of measurement is 0.87 for the overall GTA-TSES, 0.83 for the GTA-TSES-L, and 0.78 for the GTA-TSES-I. The ATI is a survey of 16 statements regarding how one approaches teaching and responses are given on a Likert scale from 1 (this item was only rarely true for me) to 5 (this item was almost always true for me). Subscales of the ATI determine whether respondents are more teacher focused (TF; indicating an information-transmission approach) or more student focused (SF; indicating a conceptual change approach), and each subscale is reported on a five-point scale. Participants responded online to both surveys at the beginning of the semester in which they participated. While teaching self-efficacy can change over the course of a semester, it is not known how or whether teaching approach changes over a short period of time in the absence of PD (Lee, 2019). Therefore, these variables were measured at the beginning of the semester to understand the teaching approaches TAs entered the semester with.

Sixteen of the 18 participants completed a postsemester structured interview (Supplemental Appendix C) that was conducted by researchers in order to gain further insight into the sources of participants' self-efficacy and its impact on their instruction. Structured questions asked during the interview included: Which tasks were you most confident in performing? Did any experiences, observations, or interactions improve your confidence? Explain any obstacles or difficulties you may have had to overcome to improve your confidence. Have there been any critical moments or pieces of information that have changed how you think about your instruction? Interviews, which lasted approximately 25 minutes, were conducted both in person and online, audio-recorded, and transcribed for analysis.

Data Analysis

Data from both surveys were averaged across all participants to give a score out of 5, including averaging the subscales of the GTA-TSES and ATI so that each participant had GTA-TSES, GTA-TSES-L, GTA-TSES-I, TF, and SF scores (Table 2). Pearson correlation coefficient analysis was used to determine any relationships between the GTA-TSES and both the TF and SF subscales, as well as between subscales of the GTA-TSES and subscales of the ATI. An alpha of 0.05 was set a priori.

Individual utterances in the responses to each interview question were analyzed. Utterances were considered as any individual statements that conveyed an idea or thought expressed within the overall answer to an interview question. Two researchers (C.S. and A.W.) coded half of the data set independently with a strong level of agreement (k = 0.87; McHugh, 2012) using a thematic framework that describes the sources of self-efficacy (Figure 2) as established in the

TABLE 2. Quantitative results of the GTA-TSES and ATI surveys and frequencies of coding categories[a]

Pseudonym	GTA-TSES	GTA-TSES-L	GTA-TSES-I	SF	TF		ME	VE	VSPP	VSPS	CL
Low group											
Ivy	3.50	3.73	3.14	3.13	2.75		—	—	—	—	—
Oakleigh	3.78	3.36	4.43	2.63	3.50		3	1	2	5	4
Bivan	3.78	3.73	3.86	3.75	3.38		—	—	—	—	—
Hector	3.89	3.82	4.00	4.13	3.63		5	3	0	3	3
Ava	3.94	3.91	4.00	2.75	3.13		6	2	0	0	4
Gretchen	4.00	3.64	4.57	3.13	3.38		2	2	1	4	7
Naomi	4.00	4.00	4.00	3.63	3.38		2	2	0	3	5
Jahi	4.00	3.64	4.57	3.25	3.00		2	1	1	2	7
						M	**3.3**	**1.8**	**0.6**	**2.8**	**5.0**
Moderate group											
Valentina	4.33	4.18	4.57	3.75	2.38		1	2	2	0	1
Everett	4.33	4.09	4.71	3.38	4.13		0	4	2	2	3
Sawyer	4.33	4.36	4.29	2.88	3.13		7	3	0	4	4
Amare	4.44	4.36	4.57	3.38	3.38		3	0	0	1	1
Nick	4.44	4.27	4.71	3.25	3.50		5	3	2	3	6
						M	**3.2**	**2.4**	**1.2**	**2.0**	**3.0**
High group											
Kensley	4.56	4.64	4.43	3.50	2.13		2	1	1	1	3
Daniella	4.78	4.82	4.71	3.00	3.25		5	2	0	3	9
Elizabeth	4.78	4.82	4.71	4.00	3.38		2	4	2	2	5
Ariana	4.83	4.73	5.00	3.63	3.38		4	2	1	0	3
Julietta	5.00	5.00	5.00	4.38	3.75		5	2	0	3	3
						M	**3.6**	**2.2**	**0.8**	**1.8**	**4.6**
M	**4.26**	**4.17**	**4.40**	**3.00**	**3.25**						
SD	**0.42**	**0.48**	**0.46**	**2.75**	**3.13**						

[a]GTA-TSES, teaching self-efficacy scale (five-point Likert scale); SF, student focused subscale of ATI (five-point Likert scale); TF, teacher focused subscale of ATI (five-point Likert Scale); ME, mastery experience; VE, vicarious experience; VSPP, verbal and social persuasions from peers and professors; VSPS, verbal and social persuasions from students, CL, concern for learning.

study by Smith and Delgado (2021) and associated with the model discussed earlier, as well as emergent codes that arose from the data. Emergent codes (identified and defined in the *Results* below) were developed as a result of the coders discussing potential codes they identified in the data that did not fit into the existing framework and coming to an agreement of how they should be categorized, whether as a new code or subcategory of an existing code. The coders then coded the entire data set together and discussed and agreed upon codes for all responses. Codes were quantified among all utterances to give the total number for each code used by each participant. The coders were blind to the GTA-TSES scores of participants while coding, and only one coder was involved in the original framework development, which aided in avoiding confirmation bias. To compare TAs with high and low self-efficacy, qualitative coding results of the participants with the highest GTA-TSES scores and the lowest GTA-TSES scores who also participated in the interview were compared to describe differences between their experiences. The findings from quantitative and qualitative analysis were integrated (converged) for triangulation.

RESULTS

First, we present the findings from research question 1 (relationship between TAs' approaches to teaching and their self-efficacy) followed by the findings from research question 2 (qualitative themes).

Relationship between TAs' Approaches to Teaching and Their Self-Efficacy

Pearson correlation coefficients showed the GTA-TSES results had a statistically nonsignificant but trending positive relationship with SF ($r = 0.39$, $p = 0.11$; Figure 3) and no relationship with TF ($r = 0.09$, $p = 0.70$; Figure 4). Therefore, quantitative results do not indicate that self-efficacy is related to teaching approach. Interestingly, we found a statistically significant strong correlation between the self-efficacy subscale (learning environment) and ATI subscales: GTA-TSES-L and TF ($r = 0.98$, $p < 0.001$) and GTA-TSES-L and SF ($r = 0.94$, $p < 0.001$). Similarly, we also found a relatively weaker significant correlation between the self-efficacy subscale (instructional strategy) and ATI subscales: GTA-TSES-I and TF ($r = 0.56$, $p < 0.05$) and GTA-TSES-I and SF ($r = 0.54$, $p < 0.05$). These findings indicate that, while overall relationships were not found between the two variables, TAs' confidence in creating a classroom environment more conducive to learning is strongly related to both teacher- and student-focused approaches. A weaker but statistically significant relationship was found between TAs' confidence in preparing and delivering content and both teaching approaches.

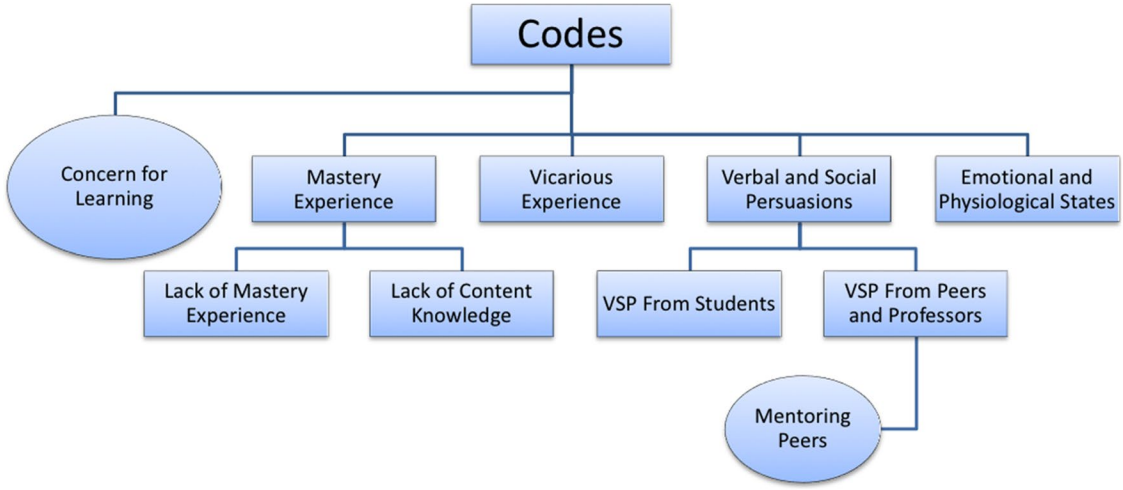

FIGURE 2. Framework adopted from Smith and Delgado (2021) used to code qualitative data related to sources of self-efficacy for teaching assistants. Novel categories are in ovals, with pre-existing categories in boxes.

Approach to Teaching and Self-Efficacy and Its Impact on the Model of TA Self-Efficacy

Participants who completed an interview were placed into three groups based on their GTA-TSES scores. Five TAs were placed into the high self-efficacy group (GTA-TSES ≥ 4.50), six TAs were placed into the low self-efficacy group (GTA-TSES ≤ 4.00), and five TAs were placed into the moderate self-efficacy group (GTA-TSES > 4.00 and < 4.50). We focused on a contrast between only high and low self-efficacy groups to understand how students on the two ends of the range differ in their teaching development and approach. We believed this approach would allow us to make more meaningful inferences from the data and match the dichotomy in the model by Smith and Delgado (2021). The high and low groups had similar levels of experience despite the high self-efficacy group being an average of 2 years older. Table 3 details the coding framework used to analyze the interviews with example quotes provided.

Despite similar frequencies of ME codes between high and low self-efficacy participants (Table 2), a major difference was observed in the context of their responses. The high self-efficacy group discussed specifically how past experiences helped them learn and develop teaching techniques that were then used to positively impact student learning. For example, Ariana, a high self-efficacy TA who applied what she learned in previous semesters for the benefit of her students, said, "I think that the second time [teaching] I tried to put a little bit more effort in preparing the class since I had a previous experience, and I knew where exactly the students had trouble last time … I knew what I was doing and the specific things to target with them." In contrast, the low self-efficacy group did not move past simply acknowledging the general benefit of having teaching experience and that it contributed to their confidence going into the semester. Ava and Naomi were two low self-efficacy TAs who discussed their experiences benefiting them only. Ava said, "I guess the more I've [taught], the more confident I've become with everything generally"; and Naomi noted, "That last semester experience really helped me make this semester go a lot more smoothly."

Both the high and low self-efficacy TA groups were coded 11 times for VE, and both mentioned either adopting favorable practices or not adopting unfavorable practices of instructors they previously had. As a high self-efficacy TA, Daniella reflected

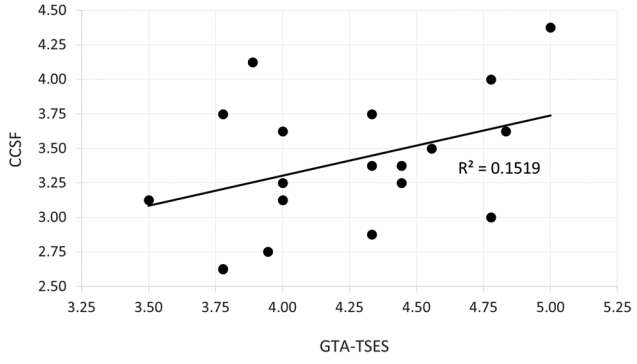

FIGURE 3. Scatterplot of relationship between self-efficacy (GTA-TSES) and student-centered teaching approach (CCSF) scores ($r = 0.39$).

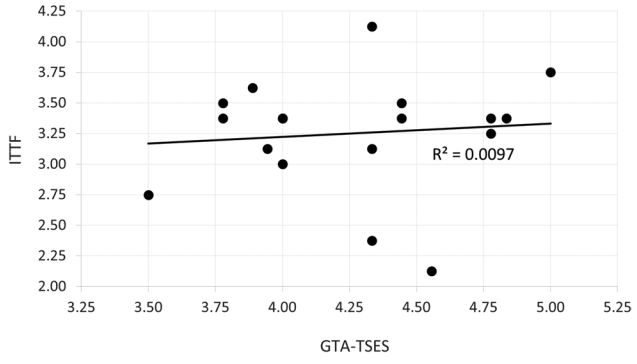

FIGURE 4. Scatterplot of relationship between self-efficacy (GTA-TSES) and teacher-centered teaching approach (ITTF) scores ($r = 0.09$).

TABLE 3. Description of coding framework of TA sources of self-efficacy with sample quotes

Category	Description	Sample quotes
Mastery experience	One's own experiences that influenced one's confidence in teaching	"Students asking me questions that I didn't specifically prepare for I'm still very confident in doing that just because of having enough experience in it."—Elizabeth, high self-efficacy "Having that last semester's experience really helped me make this semester go a lot more smoothly."—Naomi, low self-efficacy
Vicarious experience	Viewing another's teaching practices and comparing to one's own practices to influence confidence in teaching	"I tried to draw off [my professor's] approach this class while still having that casual approach to show up, work hard for me, give me what time you can, and then I'll reflect on the grades accordingly."—Kensley, high self-efficacy "Trying to make sure I have as many questions as I can is something that I've seen in some courses, and I generally like that because I'm not able to doze off when I'm in class."—Ava, low self-efficacy
Verbal and social persuasions from peers and professors	Feedback on one's teaching received from other TAs or professors that influences confidence in teaching	"The feedback [from the professor] that I got personally I think was targeted specifically to things that I can improve and if I improve those things, I will become a better TA for the students."—Ariana, high self-efficacy "Once I received feedback [on my teaching] I realized it was very thoughtful and that really helped me in some sense."—Jahi, low self-efficacy
Verbal and social persuasions from students	Feedback on one's teaching received from students that influences confidence in teaching	"I prepared some materials for teaching and made it available to the students and I heard some nice feedback that some of them actually liked to use it, so I think that kind of encouraged me during the semester."—Julietta, high self-efficacy "Just having those nonverbal cues that they're actually listening and paying attention, whether they understand or not, is really helpful."—Naomi, low self-efficacy
Concern for learning	Expressing concern for how well students are performing in one's class	"The biggest difficulty is how do you structure a class effectively with people of all different kinds of personalities and thought processes and help them all to understand the material."—Danielle, high self-efficacy "I think the students really improved from that regard. I think that improved my confidence as a TA."—Hector, low self-efficacy
Mentoring peers	Teaching confidence influenced by having other TAs reach out for help with their teaching	"When other TAs ask you for help, that's a big [confidence booster]."—Elizabeth, high self-efficacy

on her time as a student in the same class she was teaching, saying, "My TA did not really have structure to his class. He would just ask us 'what questions would you like to go over in the packet'… So, I try to be more structured than that." While describing her teaching techniques Ava, a low self-efficacy TA, explained that she tries "to make sure that I have as many kinds of questions and ways to engage [students] throughout like just coverage of content as I can is the way I've seen in some courses."

The existing coding framework differentiates between verbal and social persuasions from peers and professors (VSPP) and those from students (VSPS). VSPP appeared with similar frequency among high and low self-efficacy TAs, whereas VSPS appeared at a much higher frequency for those with lower self-efficacy (Table 2). These results suggest that, in contrast to higher self-efficacy TAs, lower self-efficacy TAs more often relied on feedback from students. Two of the four responses from low self-efficacy TAs that were coded for VSPP specifically related to feedback from supervising professors. The lack of feedback from professors was also valued, as Oakleigh said, "I don't really get feedback from the lab manager about if you're doing a good job. If I get no feedback, that's good feedback." Jahi, a low self-efficacy TA, benefited from simply having generally positive interactions with students outside his recitation time, as he said: "My confidence really increased in the big class as I was interacting with students." Jahi did not elaborate on how an increase in confidence impacted his students' learning. Kensley was part of the high self-efficacy group and changed her instruction methods after she was given feedback on her observed teaching practices by one of the instructors of the course for which she was a TA. Kensley had a contrasting response to Jahi's when she mentioned how changing her instruction method improved student engagement. She said, "Changing the instruction method helped a lot. I know the students noticed. They were engaged and at least a little bit more present." The data also revealed that TAs' confidence was boosted when TA peers reached out to them for help or advice on teaching. This finding stood out as being novel to the previously established model by Smith and Delgado (2021). Elizabeth, a high self-efficacy TA, said, "When other TAs ask you for help. That's another big one. That just helps my confidence knowing that they can turn to me." Responses similar to this example were considered to be novel evidence of VSPP and were found exclusively within the high self-efficacy group.

Responses related to feedback from students (VSPS) were different in content between the two groups. High self-efficacy TAs discussed students' engagement and learning within the course, whereas low self-efficacy TAs reflected more upon students' general experiences during class time. Hector, a low self-efficacy TA, said, "I feel like I've managed to come close to the students so they can see me as a friend probably and not just as a TA." However, higher self-efficacy participants spoke more about student engagement with class and the material that was being covered and how it might have impacted students' learning. Julietta, a high self-efficacy TA, developed her own materials for students to learn from in her class (this is

another example of high self-efficacy TAs' experiences developing their teaching skills). Julietta explained that she "heard some nice feedback from those materials that some [students] actually like to use them. So, I think that kind of helped encourage me during the semester." Julietta's response suggests that her student had a positive experience through interacting with materials intended to enhance learning, whereas Hector's response indicates he did not consider his students' experiences beyond becoming more familiar with him as a means of making him more comfortable in his role as a TA.

An emergent category that arose widely among the whole data set was concern for student learning (CL). This was applied to responses that demonstrated concern for students' understanding of course content and performance on assessments (Table 2). This finding builds upon Smith and Delgado (2021) model by providing evidence that links the previous literature regarding TA development and management of teaching issues (Nyquist and Sprague, 1998; Cho *et al.* 2011) to the model's hypothesis that TAs' concerns for students are tied to their teaching focus. We found that TAs in the high self-efficacy group articulated that they were concerned with how to directly impact student learning with the techniques they had developed and were implementing. As an example, Elizabeth, a high self-efficacy TA, said, "I was getting more questions and able to understand what students were not understanding in my recitations, so I was able to hit those points harder." In contrast, Jahi, a low self-efficacy TA, said, "I was feeling concerned about students because they are in their learning stage, and I didn't want to mess that up." This example is representative of the low self-efficacy group, who demonstrated a concern for their students but potential deficits in experience and development prevented them from discussing how to address their concerns with their teaching practices. These findings further support the notion that TAs with higher self-efficacy may be more likely to carry out student-centered teaching. Both groups demonstrated concern for their students' learning and performance, but only those high in self-efficacy also spoke to specific knowledge and practices that could influence student learning. These findings support our hypothesis based on the previous model of TA self-efficacy from Smith and Delgado that TAs with more experience and higher self-efficacy tend to be more focused on their students' success than their own actions and tasks.

DISCUSSION AND IMPLICATIONS

This study is unique, as it provides a deeper understanding of the model of TA self-efficacy (Smith and Delgado, 2021) by connecting self-efficacy to teaching approach and suggesting that high self-efficacy TAs show a greater concern for impacting student learning (outward focus) than for their own teaching tasks (inward focus). No significant relationships were found between self-efficacy and teaching approach overall. However, correlations between the subscales revealed that the learning and instruction subscales of the GTA-TSES each correlated with both subscales of the ATI, and the strength of each correlation revealed interesting differences. The self-efficacy subscale associated with learning showed much stronger correlations to both teacher- and student-focused approaches than the subscale associated with instruction. These findings suggest that TAs who reported higher teacher- or student-focused approaches are also confident in their ability to promote student learning. Our results regarding the learning self-efficacy and student-centered approach subscales support previous findings that teachers who believe students construct their own knowledge emphasize student's prior understanding in their classroom (Hashweh, 1996). Of course, these findings could also be interpreted as TAs having confidence in promoting learning regardless of their teaching approaches. There are many factors that influence both self-efficacy and teaching approach, such as who TAs observe teaching as students and what support and development they receive for their teaching (Boman, 2013; DeChenne *et al.*, 2015). Determining how self-efficacy and teaching approach are related requires more than the interpretation of correlational data.

To further support our quantitative results, qualitative findings of this study indicate that TAs who are higher in self-efficacy may have a more student-centered than teacher-centered approach to teaching; however, more research will be helpful to understanding the relationship between teaching approach and self-efficacy. Results are also reflective of previous literature that shows higher levels of self-efficacy contribute to decision making regarding classroom instruction such as implementing teaching techniques that have a positive impact on student learning (Klassen and Chiu, 2010). This is especially impactful alongside the correlation between student-centered approaches and self-efficacy in supporting student learning.

As Gormally and colleagues (2016) found, changing one's concept of teaching approach from teacher- to student-centered does not necessarily impact one's teaching techniques. Higher self-efficacy resulting from experience, observation, and constructive feedback may not directly translate into more student-centered actions. PD that seeks to change conceptions around the nature of teaching and learning is imperative to help TAs understand why student-centered approaches are important (Hammerich, 2001). Interventions that provide TAs more concrete examples of and practice with implementing student-centered approaches could also help in taking a next step from claiming an outward focus to enacting strategies that place the student at the center of the learning experience. However, self-efficacy is worth improving for the potential of TAs being more capable of shifting from a teacher- to student-centered approach.

Smith and Delgado's (2021) model of TA self-efficacy is further developed by the specification of concern for learning as an additional category for sources of self-efficacy that emerged from this study, as well as additional evidence of feedback from peers and professors within the existing framework. Figure 5 reflects changes to the model that are reflective of the findings of this study. Changes to the model are indicated by red type. The main addition to the model is the emergent category concern for learning (CL). Responses that were coded CL among the high self-efficacy group were more reflective of having an outward focus on their students' learning and their impact on it, whereas CL-coded responses among the low self-efficacy group reflected general concern for students in the absence of managing challenging teaching issues. The concerns expressed reflect how these TAs viewed their own role in their students' learning, which is likely to impact whether they enact student- or teacher-centered practices (Schoenfeld, 1998; Keys and Bryan, 2001). Other changes to the model in Figure 5 include specifying that high self-efficacy TAs experience increases in

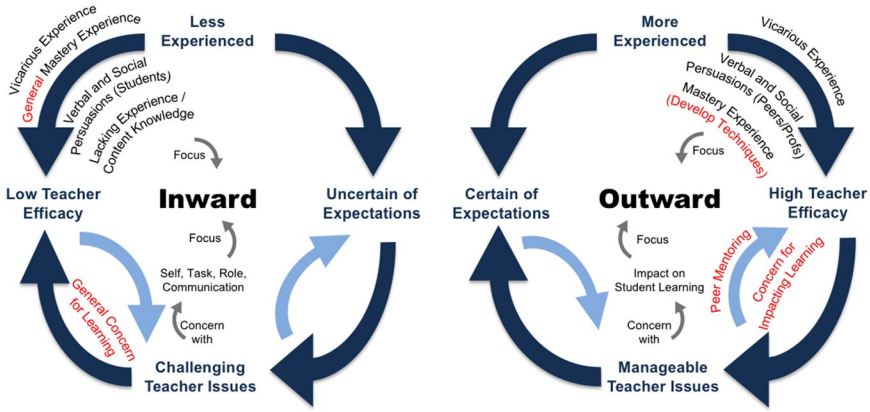

FIGURE 5. Updated model of TA self-efficacy with additions to the model in red font, including further specifying type of mastery experience, type of concern for learning, and how mentoring other TAs influences relevant variables of the model.

confidence as teaching becomes more manageable and their peers look up to them for help and advice. In terms of mastery experience, high self-efficacy TAs are cognizant of developing their teaching techniques and practices in a way that brings about greater learning in their students. Low self-efficacy TAs are more focused on their self-confidence (personal teaching efficacy) and placed less emphasis on how to positively impact student learning (outcome expectancy). Other studies conducted within the context of undergraduate field experiences (practicum) have also noted smaller gains in outcome expectancy despite opportunities to teach science in formal classroom settings (Menon and Sadler, 2016, 2018; Menon and Azam, 2021). Findings from these studies stressed the need for multiple teaching opportunities and additional mentoring to impact outcome expectancy (Menon and Sadler, 2018; Menon, 2020).

While the high self-efficacy group reflected more deeply on student concerns and learning than the low self-efficacy group, more research with a larger sample size that includes this emergent code in the model is needed to better understand the differences in TAs with inward and outward foci and how to leverage a shift from inward to outward focus. A longitudinal study of TAs with varied practical experience and levels of self-efficacy is needed to further understand the factors that lead to any potential shift in teaching approaches: Focusing on oneself versus focusing on one's impact on student learning. Further investigating the link between self-efficacy and teaching approach with a larger sample size would also clarify the relationship between these two variables. Studies that include observations of TAs' teaching are recommended to improve our understanding of whether self-reported teaching approaches (and any impact changes in self-efficacy may have on them) resonate with TAs' teaching practices and influence student outcomes.

Limitations

The relatively low number of participants in this study limits the power of quantitative findings that show relationships between the subscales of the GTA-TSES and the ATI. Additionally, collecting quantitative data presemester and qualitative data postsemester may limit comparisons of findings between the two types of data and could impact the categorization of participants' self-efficacy for qualitative analysis. Previous work by one of the authors (C.S.) to develop the model of TA self-efficacy discussed in this study may have impacted their approach to this study as well as the results of the qualitative data collected and the implications drawn from said results.

Implications for Practice

Preparing TAs for their roles as instructors of introductory undergraduate courses is difficult with so little time and limited resources for many institutions and departments. However, because TA PD is found to be beneficial to self-efficacy development, it is necessary to explore ways in which PD opportunities could be woven into TAs' schedules and responsibilities (DeChenne *et al.*, 2015). In the absence of teaching experience or pedagogical training, we recommend providing TAs, especially novice TAs, with peer and/or professorial mentorships during the first two to four semesters of instruction. One of the main differences among high and low self-efficacy groups in this study (as well as in the aforementioned model) were that the high self-efficacy group reflected on the feedback from experienced instructors, while the low self-efficacy group emphasized student interaction only. Peer and/or professorial mentorship would provide additional feedback to ensure that TAs are not only reliant on their students for feedback, which may create additional pathways to help TAs develop self-efficacy. We also believe that capitalizing on formative VE by having TAs observe teachers who practice student-centered instruction and reflect on their observations in the context of their own teaching, could also facilitate an adoption of student-centered techniques. Finally, participants in this study had not undergone any formal PD experience and therefore did not have the language needed to describe how or why their teaching techniques may have helped or not helped their students. Building pedagogical knowledge alongside opportunities for teaching practice could have a strong impact on TAs' teaching practices by developing their conceptions of teaching and learning (Hammerich, 2001).

Understanding where TAs are in their development as instructors is key to determining what information to leverage for their benefit (and the benefit of their students). Paying attention to the TAs' pedagogical preparedness as they discuss their experiences in the classroom can help instructors and administrators understand what support and mentoring TAs need. TAs who reflect on how enthused or bored students seem to be in class, or how their teaching performance is perceived by the students, could benefit from guidance on how to better support their students' learning. To be successful, TAs need constructive feedback from peers and professors as well as more knowledge on best teaching practices in their given class setting. While Gormally and colleagues (2016) mention that it takes time to overcome existing beliefs about teaching and learning, combining teaching

practice with feedback may reduce the time it takes TAs to move from teacher- to student-centered practice. Following up with these TAs on a regular basis to ask how they perceive class to be going and to observe class to see if their perception matches what is observed will reveal any progress TAs are making toward student-centered teaching practices and what, if any, other feedback or guidance should be given.

ACKNOWLEDGMENTS

We would like to thank the cooperating supervisors of our TA participants for allowing us access to our sample. There are no external financial sources of support to report, and there is no conflict of interest for any author.

REFERENCES

Auerbach, A. J. J., & Andrews, T. C. (2018). Pedagogical knowledge for active-learning instruction in large undergraduate biology courses: A large-scale qualitative investigation of instructor thinking. *International Journal of STEM Education*, *5*(1), 1–25. https://doi.org/10.1186/s40594-018-0112-9

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*, 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Hoboken, NJ: Prentice Hall.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational psychologist*, *28*(2), 117–148. https://doi.org/10.1207/s15326985ep2802_3

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Boman, J. S. (2013). Graduate student teaching development: Evaluating the effectiveness of training in relation to graduate student characteristics. *Canadian Journal of Higher Education*, *38*(3), 470–492.

Cho, Y., Kim, M., Svinicki, M. D., & Decker, M. L. (2011). Exploring teaching concerns and characteristics of graduate teaching assistants. *Teaching in Higher Education*, *16*(3), 267–279. https://doi.org/10.1080/13562517.2010.524920

Creswell, J. W. (2014). *A concise introduction to mixed methods research*. Thousand Oaks, CA: Sage.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

DeChenne, S. E., Enochs, L. G., & Needham, M. (2012). Science, technology, engineering, and mathematics graduate teaching assistants teaching self-efficacy. *Journal of the Scholarship of Teaching and Learning*, *12*(4), 102–123.

DeChenne, S. E., Koziol, N., Needham, M., & Enochs L. (2015). Modeling sources of teaching self-efficacy for science, technology, engineering, and mathematics graduate teaching assistants. *CBE—Life Sciences Education*, *14*(3), ar32. https://doi.org/10.1187/cbe.14-09-0153

Deehan, J. (2017). A review of the Science Teaching Efficacy Belief Instrument B: Pre-service teachers. In *The science teaching efficacy belief instruments (STEBI A and B)* (pp. 7–43). New York, NY: Springer.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. S., Oloroafor, N., Jodt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences USA*, *111*(23), 8410–8415. Retrieved from www.pnas.org/lookup/suppl/doi:10.1073/pnas.1319030111/-/DCSupplemental

Gardner, G., & Jones, G. (2011). Pedagogical preparation of the science graduate teaching assistant: Challenges and implications. *Science Educator*, *20*(2), 31–41.

Gormally, C., Sullivan, C. S., & Szeinbaum, N. (2016). Uncovering barriers to teaching assistants (TAs) implementing inquiry teaching: Inconsistent facilitation techniques, student resistance, and reluctance to share control over learning with students. *Journal of Microbiology & Biology Education*, *17*(2), 215–224. https://doi.org/10.1128/jmbe.v17i2.1038

Hammrich, P. L. (2001). Preparing graduate teaching assistants to assist biology faculty. *Journal of Science Teacher Education*, *12*(1), 67–82. https://doi.org/10.1023/A:1016660814622

Hashweh, M. Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching*, *33*, 47–63. https://doi.org/10.1002/(SICI)1098-2736(199601)33:1<47::AID-TEA3>3.0.CO;2-P

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching*, *48*(8), 952–984. https://doi.org/10.1002/tea.20439

Kendall, K. D., & Schussler, E. E. (2012). Does instructor type matter? Undergraduate student perception of graduate teaching assistants and professors. *CBE—Life Sciences Education*, *11*(2), 187–199. https://doi.org/10.1187/cbe.11-10-0091

Keys, C. W., & Bryan, A. B. (2001). Co-Constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching*, *38*(6), 631–645. https://doi.org/10.1002/tea.1023

Kim, E. (2009). Beyond language barriers: Teaching self-efficacy among East Asian international teaching assistants. *International Journal of Teaching and Learning in Higher Education*, *21*(2), 171–180.

Klassen, R. M., & Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of educational Psychology*, *102*(3), 741–756.

Klassen, R. M., & Tze, V. M. (2014). Teachers' self-efficacy, personality, and teaching effectiveness: A meta-analysis. *Educational research review*, *12*, 59–76. https://doi.org/10.1016/j.edurev.2014.06.001

Lee, S. W. (2019). The impact of a pedagogy course on the teaching beliefs of inexperienced graduate teaching assistants. *CBE—Life Sciences Education*, *18*(1), ar5.

McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia medica*, *22*(3), 276–282.

Menon, D. (2020). Influence of the sources of science teaching self-efficacy in preservice elementary teachers' identity development. *Journal of Science Teacher Education*, *31*(4), 460–481.

Menon, D., & Azam, S. (2021). Investigating preservice teachers' science teaching self-efficacy: An analysis of reflective practices. *International Journal of Science and Mathematics Education*, *19*(8), 1587–1607. https://doi.org/10.1007/s10763-020-10131-4

Menon, D., & Sadler, T. D. (2016). Preservice elementary teachers' science self-efficacy beliefs and science content knowledge. *Journal of Science Teacher Education*, *27*(6), 649–673. https://doi.org/10.1007/s10972-016-9479-y

Menon, D., & Sadler, T. D. (2018). Sources of science teaching self-efficacy for preservice elementary teachers in science content courses. *International Journal of Science and Mathematics Education*, *16*(5), 835–855. https://doi.org/10.1007/s10763-017-9813-7

Mills, N., & Allen, H. W. (2007). Teacher self-efficacy of graduate teaching assistants of French. In Sisken, J. (Ed.), *From Thought to Action: Explaining Beliefs and Outcomes in the Foreign Language Program* (pp. 213–234). Boston, MA: Heinle and Heinle.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of CurriculumStudies*,*19*(4),317–328.https://doi.org/10.1080/0022027870190403

Nyquist, J. D., & Sprague, J. (1998). Thinking developmentally about TAs. In Marinovich, M., Prostok, J., & Stoutt, F. (Eds.), *The professional development of graduate teaching assistants* (pp. 61–88). Bolton, MA: Anker.

Reeves, T. D., Hake, L. E., Chen, X., Frederick, J., Rudenga, K., Ludlow, L. H., & O'Connor, C.M. (2018). Does context matter? Convergent and divergent findings in the cross-institutional evaluation of graduate teaching assistant professional development programs. *CBE—Life Sciences Education*, *17*(8), 1–13. https://doi.org/10.1187/cbe.17-03-0044

Schoenfeld, A. H. (1998). Toward a theory of teaching-in-context. *Issues in Education*, *4*(1), 1–94. https://doi.org/10.1016/S1080-9724(99)80076-7

Schug, M. C. (2003). Teacher-centered instruction. In Leming, J., Ellington, L., & Porter, K. (Eds.), *A researchWhere did social studies go wrong* (pp. 94–110). Dayton, OH: The Thomas B. Fordham Foundation.

Sehgal, P., Nambudiri, R., & Mishra, S. K. (2017). Teacher effectiveness through self-efficacy, collaboration and principal leadership. *International Journal of Educational Management*, *31*(4), 505–517.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14.

Smith, C. R., & Delgado, C. (2021). Developing a model of graduate teaching assistant teacher efficacy: How do high and low teacher efficacy teaching assistants compare? *CBE—Life Sciences Education*, *20*(1), ar2. https://doi.org/10.1187/cbe.20-05-0096

Trigwell, K., & Prosser, M. (2004). Development and use of the approaches to teaching inventory. *Educational Psychology Review*, *16*(4), 409–424. https://doi.org/10.1007/s10648-004-0007-9

Trigwell, K., Prosser, M., Ramsden, P., & Martin, E. (1998). Improving student learning through a focus on the teaching context. In Rust, C. (Ed.), *Improving student learning* (pp. 97–103). Oxford, UK: Oxford Centre for Staff and Learning Development.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research*, *68*(2), 202–248. https://doi.org/10.3102/00346543068002202

Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: MIT Press; New York: Wiley.

Yost, D. S. (2006). Reflection and self-efficacy: Enhancing the retention of qualified teachers from a teacher education perspective. *Teacher Education Quarterly*, *33*(4), 59–76.

Wright, G. B. (2011). Student-centered learning in higher education. *International Journal of Teaching and Learning in Higher Education*, *23*(1), 92–97.