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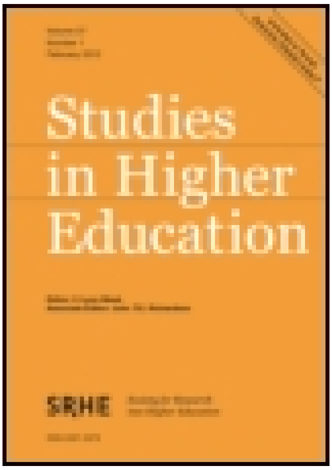

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Research indicates that modifying teachers' beliefs about learning and teaching (i.e. teaching orientation) may be a prerequisite to changing their teaching practices. This mixed methods study quantitized data from interviews with 65 graduate teaching assistants (GTAs) from science, technology, engineering, and mathematics (STEM) fields to assess the relationship of participants' teaching experiences and available teaching support systems with changes in their teaching orientation over time. These individuals represent an important but understudied link in the STEM pipeline, because they serve as primary instructors in large, introductory science laboratory classes for undergraduates at large research universities. Mentor involvement in teaching and departmental/university training and support for teaching were significantly related to change in teaching orientation toward more student-centered beliefs. Consideration of why other factors failed to evidence a relationship with teaching orientations and recommendations for how study findings can influence policy and practice are offered.

Keywords: graduate teaching assistant; teaching orientation; teacher beliefs; graduate student education; graduate student development; graduate student mentoring

Graduate teaching assistants (GTAs) have played a substantial role in the education of undergraduates in the USA for over 50 years, teaching between 25% and 50% of undergraduate courses (Moore 1991; Jones 1993; Boyer Commission 1998, 2001, Branstetter and Hendelsman 2000). These assistantships provide first-time teaching experiences for most members of the science, technology, engineering, and mathematics (STEM) professoriate (Austin 2010) and may entail the only pedagogical training they receive (Tanner and Allen 1996; Luft et al. 2004). Thus, it is critical – both for the students taught by GTAs and for the teaching effectiveness of future faculty – that GTAs

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adopt effective pedagogical practices during this induction phase, because early teaching experiences tend to establish enduring teaching skills and approaches (Boice 1996).

Despite the importance of GTAs in the academic pipeline, extant investigations of their beliefs regarding student-centered teaching approaches are limited (but see French and Russell 2002; Volkmann and Zgagacz 2004; Gilmore and Kelly 2011; Saroyan, Dagenais and Zhou 2009). Consequently, little is known about the factors associated with the development of teaching beliefs for these pivotal instructors. However, available research suggests several potential mechanisms that enhance the development of GTAs' teaching skills: faculty mentorship for teaching (Jones 1993; Boyle and Boice 1998), training and professional development (Prieto and Meyers 1999), and teaching experience (French and Russell 2002). Teachers' prior research experiences may also be pivotal in establishing their beliefs about student-centered teaching (Windschitl 2000). The current study examines the strength of associations between each of the above factors and subsequent changes in STEM GTAs' teaching orientations (i.e. 'knowledge and beliefs about the purposes and goals for teaching,' Magnusson, Krajcik and Borko 1999, 97).

Conceptual framework

Given the limited research investigating GTA teaching orientations, our consideration of relevant literature includes scholarship examining teaching orientations at both the K-12 and university levels. Additionally, we frame the study within the broader literature on graduate student development.

Teaching orientation

Teaching orientations have garnered attention in part because they are thought to predict teaching practices. As Grossman (1990, 86) stated, teaching orientations represent a 'conceptual map for instructional decision making'. Although a direct orientation–practice relationship has been challenged (Mellado 1998; Magnusson, Krajcik and Borko 1999; Simmons et al. 1999; Hativa, Barak and Semhi 2001; Feldon 2007), modification of teachers' orientations is hypothesized as a prerequisite to changing teachers' practices (Brown and Cooney 1982; Nespor 1987; Pajares 1992). In most studies, researchers have inductively developed categorizing themes. These efforts have generated numerous teaching orientation frameworks, some with as many as nine orientation categories (e.g. Magnusson et al. 1999). Kember's (1997) examination of framework commonalities and differences suggests that in all frameworks, teachers generally transition from teacher-centered to student-centered orientations over time. To date, the identification of factors that facilitate these transitions is limited. As Benford and Lawson (2001, 12) note, 'No prior studies have documented factors that lead to or result from the diversity of teaching orientations.'

Most examinations of teaching orientation focus on K-12 teachers (e.g. Mellado 1998; Simmons et al. 1999; Bryan 2003; Lam and Kember 2004; Friedrichsen and Dana 2005; Yilmaz 2008) or university faculty (Samuelowicz and Bain 1992; Hativa, Barak and Semhi 2001; see Kember 1997 for a synthesis). Saroyan, Dagenais and Zhou (2009) provide the only teaching orientation framework for GTAs. Although we also target GTAs, we deemed the framework of Saroyan and colleagues inappropriate for our purposes due to its unidimensional approach. For example, the Saroyan framework does not distinguish between GTAs' beliefs about the content of instruction and the activity of learners in the learning process. If these beliefs are consistent

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(e.g. both student-centered), this is not problematic. However, when GTAs hold student-centered beliefs about the content of instruction (e.g. 'I think it is important that the content connects with learners' prior knowledge') while expressing teacher-centered beliefs about the directionality of teaching (e.g. 'I prefer instructing students through knowledge transmission such as lecturing'), it is not possible to characterize their teaching orientation effectively under this framework.

In contrast, the framework offered by Samelowicz and Bain (1992) distinguishes between the various components that comprise a teaching orientation, such as beliefs about *what* is taught and the *way* it should be taught. This framework was developed with university faculty and serves as the framework for this study.

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Influences on GTA development

Training

GTAs receive highly variable training across institutions and departments (Boyer Commission, 1998, 2001). Training programs vary from two-hour workshops to semester-long programs (Young and Bippus 2008) and differ with respect to the number and type of topics discussed (Tanner and Allen 2006). Some GTAs receive training from their department, while others participate in programs organized at the university level (Luft et al. 2004). University-level training typically addresses university policies rather than pedagogy (Gray and Buerkel-Rothfuss 1991). Accordingly, GTAs often report perceiving university-level training as too 'diffuse' to impact their teaching (Luft et al. 2004, 219). This may explain why GTAs rarely feel prepared to teach. For example, Golde and Dore's (2004) national survey of over 4000 graduate students revealed that they were concerned about their preparation to engage in basic teaching activities including facilitating discussion-based courses, leading laboratory sections of a course, and lecturing. Such findings have prompted some universities to implement programs such as *Preparing Future Faculty* which provides systematic professional development to improve GTA teaching skills (Gaff 2002).

Despite variability in the implementation of GTA training, training programs can positively influence GTAs' teaching. For example, Prieto and Meyers (1999) report that a national sample of GTAs in psychology receiving an average of 22 hours of training evidenced significant pre-post gains in teaching efficacy (teacher's judgment of his or her ability to impact student engagement and learning).

Mentorship

Some researchers (e.g. Jones 1993) suggest that faculty mentors are more significant to the development of GTAs' teaching ability than training. This notion aligns with literature on cognitive apprenticeships, indicating that novices learn how to perform complex tasks through interacting with a master (Lave and Wegner 1991). Unfortunately, GTA mentorship is generally the responsibility of a single faculty member assigned to monitor all departmental GTAs (Shannon, Twale and Moore 1998; Byrnes 2001). Not surprisingly, GTAs commonly report receiving minimal feedback from experienced mentors regarding their teaching and particularly in terms of their instructional practices (Luft et al. 2004). Thus, Byrnes suggests that the quality of mentoring that is necessary for developing effective teaching skills may not be available to many GTAs.

Variability in the quality of GTA mentorship may explain discrepant findings regarding the relationship between mentoring and GTA teaching outcomes. For example, Prieto and Meyers (1999) did not find a relationship between ongoing mentor supervision regarding GTAs' teaching and teaching-efficacy. However, when Boyle and Boice (1998) provided funding to faculty to ensure that GTAs received regular mentoring regarding their teaching, GTAs reported learning more from their teaching experiences.

Teaching experience and teacher development models

Previous teaching experiences may also impact GTAs' teaching orientations. Models of teacher development posit that beginning teachers focus on developing 'survival' skills such as classroom management and the ability to transmit basic information (Fuller and Bown 1975, 36). Only after these are acquired do teachers turn their attention to students' needs and more nuanced pedagogical practices (Fuller 1969; Fuller and Bown 1975; Ryan 1986; Bullough 1987; Kagan 1992; Zuljan 2007). Thus, models of teacher development suggest that effective use of student-centered instruction emerges later in a teacher's career. Though Fuller's original research was conducted with pre-service teachers across a variety of fields, subsequent research conducted specifically with science and mathematics teachers supports Fuller's model (Adams and Crockover 1997).

Research with GTAs also confirms this pattern of development. For example, French and Russell (2002) found that inexperienced GTAs were commonly concerned with classroom management and described, in general terms, how they would help students to learn. These teachers largely viewed their role as delivering information to students. In contrast, experienced GTAs viewed their roles as facilitators of learning and focused more on pedagogy and the process of doing science. Thus, the extent to which GTAs have engaged in prior teaching activities may predict whether they adopt student-centered teaching approaches such as inquiry teaching methods.

Research experience

Authentic scientific inquiry experiences for teachers may also be prerequisite to implementing student-centered teaching methods in the classroom. For example, Windschitl (2000, 2003) found that research experiences impacted how pre-service K-12 teachers planned to use inquiry in the classroom. However, prior to the current study, no study has examined the relationship between research experience and beliefs about teaching among GTAs, who frequently have greater familiarity with research in the university context than their K-12 teacher counterparts. Additionally, the duration and depth of research experience necessary for teachers to enhance students' understanding of STEM is unknown (Feldman, Divoll and Rogan-Klyve 2009).

Hypotheses

Based on our review of extant literature as detailed above, we posit that four main variables impact GTAs' teaching orientations: mentorship, training for teaching, teaching experience/teacher development, and research experience. Further, based on the literature summarized above, we hypothesize that each is positively associated with GTAs' development of teaching orientations that over time become more student-centered.

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Method

We employed a mixed methods design with qualitative data collection and both qualitative and quantitative data analysis. Semi-structured, one-on-one interviews were conducted with three cohorts of GTAs and their self-identified mentors at the beginning and end of an academic year (2007–2008, 2008–2009, or 2009–2010). Interviews were transcribed and coded as described below. Data were quantitized to facilitate statistical analyses of the relative strengths of association between the four factors (mentorship, training, teaching experience/teacher development, and research experience) and change in GTAs' teaching orientations. Additional qualitative analyses provided insight into participants' experiences with each factor and its perceived influence on teaching orientations.

Participants and context of study

Researchers recruited participants as part of a National Science Foundation (NSF) study (see Feldon et al. 2011; Timmerman et al. 2011) conducted to investigate the effect of inquiry-based teaching on STEM methodological skill development. Findings from this larger study empirically established a link between inquiry-based teaching and skill development, but did not address teaching orientation development, as does the current study. Here we report on 65 GTAs who taught in formal instructional settings during their participation. Participants were enrolled in STEM masters and doctoral programs at three universities. Two institutions are located in the Southeastern USA, including a research-extensive university (73.8% of sample) and a primarily baccalaureate college of arts and sciences with a research-intensive masters program (13.8%). The third, a larger masters-granting university (12.3%), is located in the Northeast.

Participants worked as traditional university-level GTAs ($n = 32$), co-taught in middle school through the Graduate Teaching Fellows in K-12 Education[1] (GK-12) program or a similar university-funded program that mirrors GK-12 ($n = 20$ and 8, respectively), or were full-time teachers in K-12 education or at local colleges in STEM ($n = 5$). The sample was heavily weighted toward the sciences (55.4%) and engineering (18.5%, see Table 1). Over 60% of participants were first-year graduate students, and 20% were non-native speakers of English.

Data analysis

Participant transcripts were compiled in *NVivo 8* for data storage, exploration, and organization. Each of the 65 participants was interviewed at the beginning and at the

Table 1. Number of participants by teaching status and field.

	University GTA	GK-12/similar university program	K-12 or college teacher
Science	21	15	0
Technology	2	2	0
Engineering	1	11	0
Mathematics	6	0	0
Science/mathematics Education	2	0	5

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end of an academic year, generating 130 transcripts. These transcripts were coded according to the framework of Sameulowicz and Bain (1992). As shown in Table 2, five teaching orientation dimensions comprise the framework. For each, individuals' beliefs are coded as either *student-centered* or *teacher-centered*. The number of dimensions coded *student-centered* can be tallied to compute a total teaching orientation score with a range of 0 to 5.

The first author and a second rater coded 47 randomly selected interview transcripts representing 36.2% of the total sample (65 pre-transcripts and 65 post-interview transcripts for a total of 130 transcripts) according to the coding scheme. Exact inter-rater agreement was highest for Outcome of Instruction (exact agreement = 89.4%) and Students' Conceptions (exact agreement = 85.1%). Inter-rater agreement was most problematic for Directionality of Teaching (exact agreement = 61.7%). Upon review of the data, discrepancies often occurred because interviewees expressed conflicting perspectives within the same interview. All discrepant scores were resolved through discussion until consensus was reached (Johnson et al. 2005). The first author then individually coded the remaining 83 transcripts.

Not all interviews yielded participant responses sufficient to code on all five dimensions. For the pre-interview and post-interviews, 2.8% and 7.4% of the data were missing (Table 2). To permit statistical analysis of responses from all participants, including those who did not address all dimensions, multiple imputation procedures

Table 2. Overview of the Samuelowicz and Bain (1992) teaching orientation framework and application in this study.

Dimension	Teacher-centered	Student-centered	Exact agreement (%)	% Missing data (%)	
				Pre-interview	Post-interview
1. Outcome of instruction	Quantitative/ learn more	Qualitative/ perspective change	89.4	0.0	7.7
2. Knowledge gained or constructed	Student learns subject-matter knowledge	Student learns something that connects to the real world, helps them make sense of reality	74.5	1.5	6.2
3. Students' conceptions	Teacher does not consider students' prior knowledge	Teacher considers students' prior knowledge when designing instruction	85.1 61.7	6.2 0.0	16.9 0.0
4.Directionality of teaching	One-way transmission/ the teacher teaches the student	Bi-directional learning/both teacher and student are involved	72.3	7.7	9.2
5. Control of content	Teacher determines the content	Students have input into the content			

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were used to create a complete dataset. Stata's multiple imputation (MI) multivariate normal procedure was used. MI Impute was used to create 10 datasets and MI Estimate was used to combine the 10 datasets.

After coding and imputation, the number of dimensions on which each participant was identified as holding a student-centered belief was tallied, providing a total teaching orientation score. For example, if participants were coded as holding student-centered beliefs about dimensions 1–3 and teacher-centered beliefs about dimensions 4 and 5, they received a total orientation score of 3. To examine teaching orientation development, changes in total orientation scores were calculated from the pre- to the post-interview. Total orientation scores were not always a whole number due to imputation procedures.

Participants' experiences were categorized with respect to the four factors expected to be associated with teaching orientation change. First, transcripts were coded for information regarding the presence or absence of mentor involvement in teaching. The first author examined both mentor and participant interviews to triangulate information regarding mentor involvement in participants' teaching activities. These data were coded using three ordinal categories: (1) no support/involvement in participants' teaching; (2) indirect/informal involvement; or (3) direct involvement.

Training participants received for their teaching was coded as either a 0 or 1. A code of 0 indicated that the participant did not receive ongoing training for their teaching from their department or university between the fall and spring interview. A code of 1 indicated receipt of training, generally weekly meetings during which participants discussed their teaching with other GTAs. Almost all study participants attended a mandatory university-wide teaching orientation. However, this experience was not coded as evidence of training, because this training was brief (two days) and occurred prior to the start of the semester. Moreover, as discussed above, university-wide GTA training typically focuses on university policies and resources rather than pedagogy (Gray and Buerkel-Rothfuss 1991; Luft et al. 2004). The amount of professional scholarly experience that participants self-reported (duration of prior research experience coded in number of semesters and duration of prior teaching experience coded in number of years) was also noted from the interviews.

After coding, a multiple regression was conducted in which independent variables (hypothesized sources of development including mentorship, ongoing training, prior teaching experience, and prior research experience) were examined in their relation to change in teaching orientation total scores from the pre- to the post-interview. Because mentor involvement in teaching had three ordinal levels, it was dummy coded when included in the regression model.

Results

Descriptive analyses are first presented for each of the four independent variables, followed by results from the ordinal regression. The regression assesses the relative observed strength of association between each factor and changes in participants' total orientation scores.

Qualitative results

Mentorship

Both pre- and post-participant and mentor interviews were examined for evidence that participants' mentors were involved in their teaching. Incomplete data did not allow mentor involvement to be determined for 13 participants. Over 20% of participants were categorized as having mentors who were not involved in their teaching. Typically, these participants and their mentors noted that their relationship focused on the participant's research or coursework rather than teaching. Participants also often taught outside of fields in which their mentors held expertise. Thus, they may have sought advice about teaching from someone with more closely related experience. This disconnect was also commonly observed among GK-12 participants because their mentors were not active at the K-12 schools in which they taught. A few instances were noted, however, in which the participants' mentor was generally unavailable and thus not involved in any aspects of the participants' development.

We identified 50% of participants as having mentors who were informally/indirectly involved in their teaching. This type of support was characterized by participants conversing with their mentors about their teaching. However, these conversations were typically infrequent, unstructured, and not based on mentor observations of participants' teaching. One mentor who described this kind of interaction noted about his advisee:

> I haven't really been directly involved with his teaching … and so we have talked many times about the classes that he's been in with me … Almost indirectly we have talked about some of my teaching approaches.

We coded almost 30% of participants as having mentors who were directly involved in their teaching. For example, one mentor simply noted, 'I visited her class, saw her teach and actually helped her with a thing that day with a class and conducting electricity. And I meet with her once a week.' Although several mentors with direct involvement in participants' teaching activities described conducting observations, few of these mentors or their mentees actually described providing/receiving feedback from this process. One participant who did describe providing teaching feedback to his mentee voiced the concern that the student's passion for teaching could conflict with his other roles as a graduate student:

> He will undoubtedly land a teaching award one day. His evaluations are off the scale and he has taken on an extra teaching load. His calculus professor says he's fantastic. The students say he is fantastic but I actually called him into my office and was like 'First, I want to congratulate you on your really stellar teaching evaluations but I also want to caution you, you are here as a PhD student and I am a little worried that you will put your students ahead of yourself.'

Thus, even when mentors are directly involved in participants' teaching, they may not be supportive, though this was not typically the case.

Training

Both sets of interviews were examined for evidence that participants were involved in ongoing training programs during the intervening academic year. Of the 65 participants, 44 (67.7%) reported receiving ongoing training. Participants receiving teaching training typically noted that it occurred through weekly meetings. Often, participants described these meetings as an opportunity for the lab coordinator to tell them about the required curriculum or experiments for the upcoming lectures or labs that they would lead. Less commonly, participants described their weekly meetings as an

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opportunity to collaborate with others on the development of the curriculum, instructional activities, or classroom assessments. Almost all who described the latter type of meetings were involved in the GK-12 programs. For example, one participant described it as:

> Sometimes [the instructor] will bring in something, but a lot of times, it's just talking with the other … fellows that are doing the program and teaching 7th grade and just bouncing ideas off them about what works. It's really just communicating with them and developing ideas.

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Quantitative results

Descriptive statistics

Descriptive statistics were computed for each of the four variables analyzed (mentorship, training, prior teaching experience, and prior research experience). Average change in teaching orientation scores was compared across level of mentor involvement. Findings indicated that participants who reported more mentor involvement in their teaching showed larger gains in their teaching orientation change score. As shown in Table 3, for the 11 participants with no mentor involvement in their teaching, the average teaching orientation change score was –.496 (SD = 1.278) compared to .062 (SD = 1.661) for the 27 participants with indirect mentor involvement in teaching and 1.201 (SD = 1.526) for the 16 participants who experienced direct mentor involvement in their teaching. Independent sample *t*-tests indicate that there were significant differences in teaching orientation change score for (1) participants who had mentors who were not involved in their teaching versus those with mentors who were directly involved in their teaching ($t = -3.130$, df = 23.902, $p = .005$); and (2) participants whose mentors were indirectly involved in their teaching versus those who had mentors who were directly involved in their teaching ($t = -2.289$, df = 33.836, $p = .028$). No significant differences were observed between participants whose mentors were not involved in their teaching versus those whose mentors were indirectly involved in their teaching ($t = -1.114$, df = 24.110, $p = .276$).

Average change in teaching orientation scores were computed by receipt of ongoing training from department or university. Findings indicated minimal, non-significant difference between participants who were involved in ongoing training versus those that were not. As shown in Table 4, for the 21 participants who were not involved in ongoing training, the average teaching orientation change score was

Table 3. Teaching orientation change scores by level of mentor involvement.

	Level of mentor involvement		
	No mentor involvement	Indirect mentor involvement	Direct mentor involvement
n	11	27	16
Average teaching orientation change score	–0.496	0.062	1.201
Standard deviation of teaching orientation change score	1.278	1.661	1.526

Table 4. Teaching orientation change scores by receipt of ongoing training and support for teaching.

	Receipt of ongoing training and support for teaching	
	No training	Training provided
n	21	44
Average teaching orientation change score	0.234	0.190
Standard deviation of teaching orientation change score	1.507	1.630

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.234 (SD = 1.507) compared to .190 (SD = 1.630) for the 44 participants who were involved in ongoing training ($t = 0.104$, df = 63, $p = .917$).

Substantial variability in the duration of participants' prior teaching experience was observed. Of 65 participants, 27 (41.5%) reported no teaching experience. Of those with teaching experience, the length of this experience ranged from half a year to 23 years, with a mean of 4.59 ($n = 38$, SD = 5.51) years of teaching experience. Among all participants, the mean number of years of teaching experience was 2.65 ($n = 65$, SD = 4.77). Table 5 presents the average duration of teaching experience for all participants. Figure 1 presents change in participants' total teaching orientation score by duration of teaching experience. As detailed, no robust pattern was observed between the two variables.

Similar to teaching experience, considerable variability in the duration of participants' prior research experience was observed. Research experience was measured in semesters. Six of 64 (9.4%) participants reported no research experience. Prior research experiences varied in duration between 1 and 20 with a mean of 3.39 ($n = 57$ [data were unavailable for one participant], SD = 3.01) semesters of research experience. As shown in Table 5, among the 64 participants who reported duration of prior research experience, the mean number of semesters was 3.20 ($n = 64$ [data were unavailable for one participant], SD = 3.23). Figure 2 presents change in participants total teaching orientation score by duration of research experience. As it shows, no robust pattern was observed between the two variables.

Ordinal regression results

We used ordinal regression to examine the relationship between four independent variables (mentor involvement in teaching, training from department or university, prior

Table 5. Average duration (and standard deviation) of teaching and research experience.

	Duration of prior experiences	
	Teaching experience (reported in years)	Research experience (reported in semesters)
n	65	64
Average duration	2.646	3.200
Standard deviation of duration	4.770	3.233

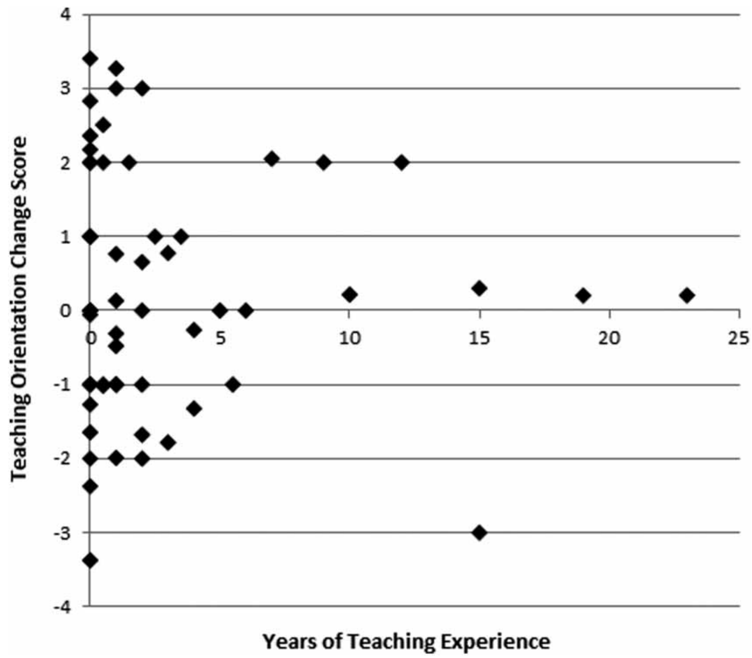

Figure 1. Teaching orientation change score by duration of teaching experience.

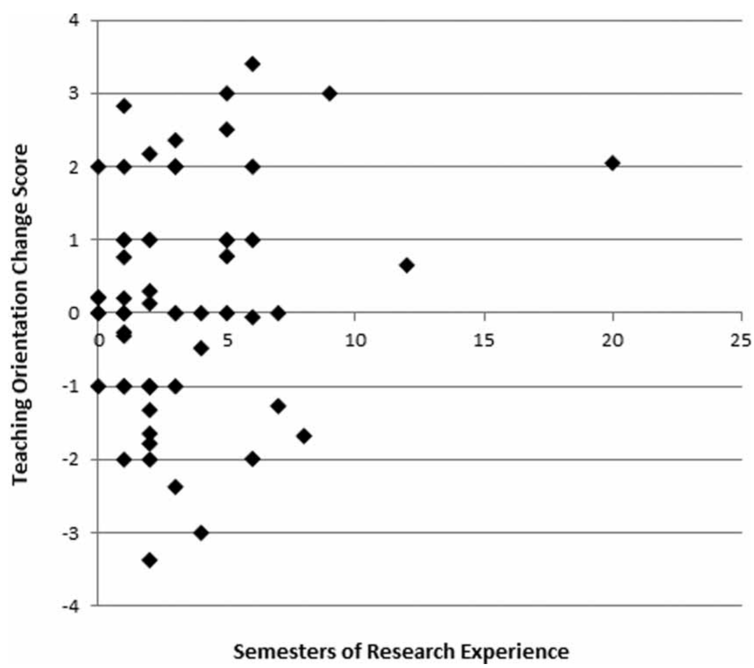

Figure 2. Teaching orientation change score by duration of research experience.

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teaching experience, and prior research experience) and change in participants' teaching orientations. Table 6 presents correlations between these variables. As it shows, years of teaching experience was significantly negatively correlated with receipt of ongoing training or support for teaching (rho = –.296, $p = .016$). Table 6 also shows that teaching orientation change score was positively associated with mentor involvement in teaching where higher levels of mentor involvement were related to larger gains in the teaching orientation score (rho = .360, $p = .008$). Table 7 presents parameter estimates resulting from the ordinal regression. As predicted, higher levels of mentor involvement in teaching had a positive association with teaching orientation change. Because mentorship had more than two categories, the intervals between the ordered categories may not have been the same. This may have resulted in differing effects or coefficients between levels. Table 3 reflects this – going from mentor involvement of 1 (no support/involvement) to 3 (direct involvement) had a larger positive impact on participants' teaching orientation change scores than going from 1 to 2 (indirect mentor involvement/support). The impact of moving from no mentor support/involvement to direct involvement was significant ($p = .02$).

Departmental or institutional training during the academic year was found to have a non-significant relationship with change in teaching orientation ($p = 0.341$). No significant relationship was found between either teaching or research experience and change in teaching orientation ($p = .738$ and 0.213, respectively).

Discussion

Four factors (mentor involvement in teaching, training from department or university, prior teaching experience, and prior research experience) were predicted to be related to change in participants' teaching orientations. Surprisingly, neither the duration of GTAs' prior teaching or research experience were significantly related to change in teaching orientation over time. It is possible that the quality or nature of teaching and research experiences is more important than their duration. Findings of this study indicate that although few GTAs reported having no prior research experience, about half reported having no prior formal teaching experience. This finding likely reflects the limited number of teaching experiences that are available for undergraduates due, in part, to college accreditation requirements that instructors hold degrees. In contrast, universities frequently promote undergraduate research activity (Council on Undergraduate Research 2005).

Mentor involvement in GTAs' teaching was positively associated with change in teaching orientation. However, the relationship between involvement and teaching orientation change was only significant when no support/involvement was compared with direct involvement ($p = .020$). This finding is aligned with previous work which indicates that mentors should be directly involved in GTAs' teaching (e.g. Boyle and Boice 1998).

The relationship between departmental or university training for teaching and teaching orientation change was not significant. It is likely that this is due to inadequate statistical power which was computed in *GPower 3.1.0* to be .165. Post-hoc analysis of statistical power indicated that a sample size of 420 participants would be needed to get significant results 80% of the time. Although quantitative analysis did not support that ongoing training is significantly related to participants' belief change, the importance of this type of interaction was noted by participants. Specifically, several participants mentioned the value of discussions with peers through a required course provided through GK-12, and several participants identified discussions with

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Table 6. Correlations between variables investigated.

		Teaching orientation change score	Years of teaching experience	Semesters of research experience	Receipt of ongoing training and support	Mentor involvement in teaching
Teaching orientation change score	Spearman's rho	1.000	–.004	.135	–.026	.360**
	Sig. (2-tailed)	.	.978	.287	.835	.008
	n	65	65	64	65	54
Years of teaching experience	Spearman's rho	–.004	1.000	.002	–.296*	.013
	Sig. (2-tailed)	.978	.	.990	.016	.928
	n	65	65	64	65	54
Semesters of research experience	Spearman's rho	.135	.002	1.000	.229	.030
	Sig. (2-tailed)	.287	.990	.	.069	.831
	n	64	64	64	64	53
Receipt of ongoing training and support	Spearman's rho	–.026	–.296*	.229	1.000	.091
	Sig. (2-tailed)	.835	.016	.069	.	.514
	n	65	65	64	65	54
Mentor involvement in teaching	Spearman's rho	.360**	.013	.030	.091	1.000
	Sig. (2-tailed)	.008	.928	.831	.514	.
	n	54	54	53	54	54

Note: **Correlation is significant at the 0.01 level. Sig. represents the two-tailed value for statistical significance. *n* represents the number of participants.

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Table 7. Multiple regression parameters.

Variable	Coefficient estimate	SE	t	*p*
Constant	–.495	.705	–.70	.486
Research experience	.092	.073	1.27	.213
Teaching experience	–.015	.047	–0.34	.738
Training	–.522	.543	–.96	.341
Mentor support (no support versus informal involvement/support)	.742	.591	1.26	.216
Mentor support (no support versus direct involvement)	1.541	.637	2.42	.020*

Note: *Significant at alpha = .05. SE represents the standard error in measurement. t is the test statistic. *p* represents the p-value.

other teachers as helpful. These results reflect potential benefits for programs that encourage GTAs to regularly communicate with each other about their teaching. Prior research on graduate student socialization has also documented the importance of support groups and interacting with other graduate students (Puccio 1988; Jones 1993; Austin 2002; Austin and McDaniels 2006; Sweitzer 2009).

Limitations

The nature of data collection as part of a larger study presents a primary limitation, because specific attention to the types of teaching support provided to students emerged over time. Thus, the interview protocol could have been more targeted, consistent, and comprehensive. As such, a small percentage of participants involved in the first years of data collection were not asked some of the interview questions used in subsequent years. This issue can also be viewed as a methodological strength – new insights emerged over time through iterative qualitative analysis and the interview protocol was adjusted to explore these issues.

The interview protocol also emphasized teaching skill development more heavily than previous studies on teaching orientation, which typically emphasize teaching beliefs. This shift may have limited reliability and specificity in the identification of GTAs' teaching orientations. However, these findings also demonstrate that similar constructs arise naturally during conversations with teachers about their teaching, even when the interview protocol does not specifically target teaching orientation.

A final limitation concerns the extent to which the findings may be generalizable. This study only included GTAs from three universities. Thus, the role of institutional context cannot be dismissed as a potential factor. However, the inclusion of universities that varied in size, geographic location, and Carnegie classification likely mitigate this concern. Similarly, although participants were recruited from a variety of STEM fields, the sample was heavily weighted toward the sciences and engineering. Thus, findings may be more applicable to GTAs in those fields.

Directions for future research

The strongest finding from this study concerns the importance of mentors' involvement in GTAs' teaching. Additional research is needed to identify mentoring practices that

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best facilitate teaching and learning belief development. Some work has been conducted in this area (e.g. Barnes and Austin 2009); however, it has not been specific to mentorship around teaching. Future studies providing a more in-depth analysis of mentoring practices may identify specific facets of these experiences that are differentially beneficial for GTAs. A more in-depth study of the interactions that occur during training and other forms of support may also provide insights about the ways in which these experiences should be designed to best meet GTAs' needs. In addition, future studies should include additional variables that may impact GTAs' teaching orientations such as their experiences as students. We would have liked to include this variable in our analysis; however, we did not have access to these data.

More research is also needed on the development of teaching orientations. As a whole, this study identified limited growth in participants' teaching orientations during this study. Participants' teaching orientations also regressed to more teacher-oriented strategies nearly as often as they shifted to more student-centered strategies. This may provide evidence of the relatively unstable nature of inexperienced teachers' beliefs. This finding may also reflect the challenge of aggregating teaching orientation dimensions into a total teaching orientation score, because the total score may be a problematic way to examine growth if orientation dimensions change at different rates.

Additional research can complement this study by investigating the impact of socialization experiences on GTAs' teaching skill development. Scholarship in this area either does not connect socialization experiences to teaching outcomes (e.g. Boyle and Boice 1998) or relies on self-report measures such as interviews (e.g. Austin 2002; Sweitzer 2009) or survey data (e.g. Norris and Palmer 1998; Preito and Meyers 1999; Golde and Dore 2001) to assess GTAs' preparation for teaching, teaching skills, or teaching behaviors. It is necessary to extend this work to include observations of GTAs' teaching skills (Feldon, Maher and Timmerman 2010).

Recommendations for practice

Socialization includes both formal components (e.g. activities explicitly designed to impact graduate student development such as dissertation defenses) and informal components (e.g. interactions with peers and mentors that occur in 'laboratories, research meetings, classes, and the hallway'; Austin and McDaniels 2006, 414). Informal socialization processes that include both vertical (mentor–graduate student) and horizontal (graduate student–graduate student) interactions are often subtle and brief, but provide important expressions of values (e.g. Boyle and Boice 1998; Colbeck, O'Meara and Austin 2008).

Interactions between mentors and their graduate students around teaching are uncommon (Luft et al. 2004). However, this study, coupled with prior research, supports that when mentors are actively involved in their graduate students' teaching, graduate students will show more professional growth (e.g. Boyle and Boice 1998). Thus, promoting these interactions and removing barriers that prevent these interactions may be beneficial. For example, supervision of GTAs is generally the responsibility of one over-worked faculty member in the graduate students' department (Byrnes 2001; Shannon, Twale and Moore 1998). Universities can address this concern by ensuring that faculty mentors are not overextended. Adjunct faculty may be used to free up time for tenure-track faculty to talk with their GTAs about teaching, co-teach with GTAs, and observe their GTAs' teaching and provide feedback.

Interactions between graduate students are also important in shaping their identity development (Puccio, 1988; Staton and Darling, 1989; Jones, 1993; Weidman, Twale, and Stein; 2001; Austin, 2002; Austin and McDaniels, 2006; Sweitzer, 2009). As Austin and McDaniels (2006, 402) noted, through interactions with others, graduate students learn 'what is valued, what work is done, how colleagues interact, and what the role of a faculty member involves'. Qualitative findings suggest that these interactions are related to GTA teaching orientation development. Coupled with the extant literature, this study supports the practice of regular meetings for GTAs to discuss their teaching. These group meetings give rise to a supportive culture that can converge with individual support from advisors to solidify socialization effects that address teaching beliefs. In terms of designing training and support programs, participants identified different aspects of the meetings (e.g. discussions with faculty, discussions with peers, topical presentations) as helpful. Thus, it may be beneficial to provide GTAs with a diversity of experiences during weekly support groups.

The significance of GTAs in undergraduate STEM education should not be overlooked. It is hoped that this study will contribute to the understanding and improvement of their teaching.

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Note

1. The GK-12 programs examined in this study used an immersion model in which a single graduate teaching fellow works directly with one or two classroom teachers and their students for a school year. Additionally, GK-12 provides opportunities for fellows to reflect on their teaching practices through required weekly meetings with other fellows.

References

Adams, P.E., and G.H. Crockover. 1997. Concerns and perceptions of beginning secondary science and mathematics teachers. *Science Teacher Education* 81, no. 1: 29–50.

Austin, A.E. 2002. Preparing the next generation of faculty: Graduate school as socialization to the academic career. *The Journal of Higher Education* 73, no. 1: 94–122.

Austin, A.E. 2010. Reform efforts in STEM doctoral education: Strengthening preparation for scholarly careers. In *Higher education: Handbook of theory and research*, Vol XXV. ed J.C. Smart, 91–128. Netherlands: Springer.

Austin, A.E., and M. McDaniels. 2006. Preparing the professorate of the future: Graduate student socialization for faculty roles. In *Higher education: Handbook of theory and research,* Vol XXI. ed. J.C. Smart, 397–456. Netherlands: Springer.

Barnes, B.J., and A.E. Austin. 2009. The role of doctoral advisors: A look at advising from the advisor's perspective. *Innovations in Higher Education* 33: 297–315.

Benford, R., and A.E. Lawson. 2001. Relationships between effective inquiry use and the development of scientific reasoning skills in college biology labs. Research report to the National Science Foundation. http://www.eric.ed.gov/

Boice, R. 1996. *First-order principles for college teachers: Ten basic ways to improve the teaching process*. Bolton, MA: Anker Publishing.

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Boyer Commission. 1998. *Reinventing undergraduate education: A blueprint for America's research universities*. Washington, DC: Carnegie Foundation for the Advancement of Teaching.
Boyer Commission. 2001. Reinventing undergraduate education. Three years after the Boyer Report: Results from a survey of research universities. Washington, DC: National (Boyer) Commission on Educating Undergraduates in the Research University.
Boyle, P., and B. Boice. 1998. Systematic mentoring for new faculty teachers and graduate teaching assistants. *Innovative Higher Education* 22, no. 3: 157–79.
Branstetter, S.A., and M.M. Hendelsman. 2000. Graduate teaching assistants: Ethical training, beliefs, and practices. *Ethics and Behavior* 10, no. 1: 27–50.
Brown, C.A., and T.J. Cooney. 1982. Research on teacher education: A philosophical orientation. *Journal of Research and Development in Education* 15, no. 4: 13–18.
Bryan, L.A. 2003. Nestedness of beliefs: Examining a prospective elementary teacher's beliefs system about science teaching and learning. *Journal of Research in Science Teaching* 40, no. 9: 835–68.
Bullough, R.V., Jr. 1987. Planning and the first year of teaching. *Journal of Education for Teaching* 13: 231–50.
Byrnes, H. 2001. Toward a comprehensive conceptualization of TA education: Contents, commitments, structures. Paper presented at the Annual Meeting of the International Conference on Language Teacher Education. May 17–19, Minneapolis, MN. http://www.eric.ed.gov/
Colbeck, C.L., K. O'Meara, and A. E. Austin, ed. 2008. *New Directions for Teaching and Learning* 113. Educating integrated professionals: Theory and practice on preparation for the professoriate. San Francisco, CA: Jossey-Bass.
Council on Undergraduate Research. 2005. Joint statement on principles of support of undergraduate research, scholarship and creative activities. http://www.cur.org/SummitPosition.html
Feldman, A., K. Divoll, and A. Rogan-Klyve. 2009. Research education of new scientists: Implications for science teacher education. *Journal of Research in Science Teaching* 46, no. 4: 442–59.
Feldon, D.F. 2007. Cognitive load and classroom teaching: The double-edged sword of automaticity. *Educational Psychologist* 42, no. 3: 123–37.
Feldon, D.F., M. Maher, and B. Timmerman. 2010. A call for performance-based data in the study of STEM graduate education. *Science* 329: 282–83.
Feldon, D.F., J. Peugh, B.E. Timmerman, M.A. Maher, M. Hurst, D. Strickland, J. Gilmore, and C. Stiegelmeyer. 2011. Graduate students' teaching experiences improve their methodological research skills. *Science* 333, no. 6045: 1037–39.
French, D., and C. Russell. 2002. Do graduate teaching assistants benefits from teaching inquiry based laboratories? *Bioscience* 52, no. 11: 1036–41.
Friedrichsen, P.M., and T.M. Dana. 2005. Substantive-level theory of highly regarded secondary biology teachers' science teaching orientations. *Journal of Research in Science Teaching* 42, no. 2: 218–44.
Fuller, F.F. 1969. Concerns of teachers: A developmental conceptualization. *American Educational Research Journal* 6, no. 2: 207–26.
Fuller, F.F., and O.H. Bown. 1975. Becoming a teacher. In *Teacher education: 74th yearbook of the National Society for the Study of Education, part II,* ed. K. Ryan, 25–52. Chicago: University of Chicago Press.
Gaff, J.G. 2002. The disconnect between graduate education and the realities of faculty work: A review of recent research. *Liberal Education* 88, no. 3: 6–13.
Gilmore, J., and M. Kelly. 2011. Development of science, technology, engineering, and mathematics graduate teaching assistants' beliefs about student-centered teaching. Paper presented at Eastern Educational Research Association, February 2011, in Sarasota, FL.
Golde, C.M., and T.M. Dore. 2001. At cross purposes: What the experiences of doctoral students reveal about doctoral education. www.phd-survey.org. Philadelphia, PA: Pew Charitable Trusts.
Golde, C.M., and T.M. Dore. 2004. The survey of doctoral education and career preparation: The importance of disciplinary contexts. In *Path to the professoriate: Strategies for enriching the preparation of future faculty,* ed. D.H. Wulff, A.E. Austin, and associates. San Francisco: Jossey-Bass.

Downloaded by [Utah State University Libraries] at 10:12 19 September 2014

Gray, P.L., and N. Buerkel-Rothfuss. 1991. Teaching assistant training: A view from the top. In *Preparing the professorate of tomorrow to teach*, ed. J.D. Nyquist, R.D. Abbott, D.H. Wulff and J. Sprague, 29–39. Dubuque, IA: Kendall/Hunt.

Grossman, P. 1990. *The making of a teacher*. New York: Teachers College Press.

Hativa, N., R. Barak, and E. Semhi. 2001. Exemplary university teachers: Knowledge and beliefs regarding effective teaching dimensions and strategies. *The Journal of Higher Education* 72, no. 6: 699–728.

Johnson, R.L., J. Penny, B. Gordon, S.R. Shumate, and S.P. Fisher. 2005. Resolving score differences in the rating of writing samples: Does discussion improve the accuracy of scores? *Language Assessment Quarterly: An International Journal* 2, no. 2: 117–46.

Jones, J.L. 1993. TA training from the TA's point of view. *Innovative Higher Education* 18, no. 2: 147–61.

Kagan, D.M. 1992. Professional growth among preservice and beginning teachers. *Review of Educational Research* 62, no. 2: 129–69.

Kember, D. 1997. A reconceptualisation of the research into university academics' conceptions of teaching. *Learning and Instruction* 7, no. 3: 255–75.

Lam, B.H., and D. Kember. 2004. Conceptions of teaching art held by secondary school art teachers. *Journal of Art and Design Education* 23, no. 3: 290–301.

Lave, J., and E. Wenger. 1991. *Situated learning. Legitimate peripheral participation*. Cambridge: University of Cambridge Press.

Luft, J.A., J.P. Kurdziel, G.H. Roehrig, and J. Turner. 2004. Growing a garden without water: Graduate teaching assistants in introductory science laboratories at a doctoral/research university. *Journal of Research in Science Teaching* 41, no. 1: 211–33.

Magnusson, S., J. Krajcik, and H. Borko. 1999. Nature, sources, and development of pedagogical content knowledge for science teaching. In *Examining Pedagogical Content Knowledge*, ed. J. Gess-Newsome and N. Lederman, 95–128. Boston: Kluwer Publishing.

Mellado, V. 1998. The classroom practice of preservice teachers and their conceptions of teaching and learning science. *Science Education* 82: 197–214.

Moore, R. 1991. Preparing graduate teaching assistants to teach biology. *Journal of College Science Teaching* 20: 358–61.

Nespor, J. 1987. The role of beliefs in the practice of teaching. *Journal of Curriculum Studies* 19: 317–28.

Norris, P.M., and S.C. Palmer. 1998. Effectiveness of the Woodruff School Doctoral Teaching Intern Program. *Journal of Engineering Education* 87: 223–26.

Pajares, M.F. 1992. Teacher beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research* 62, no. 3: 307–22.

Prieto, L.R., and S.A. Meyers. 1999. Effects of training and supervision on the self-efficacy of psychology graduate teaching assistants. *Teaching of Psychology* 26, no. 4: 264–66.

Puccio, P. 1988. Graduate instructor representation in writing programs: Building communities through peer support. Paper presented at the annual meeting of the Conference on College Composition and Communication, in St. Louis, Missouri. http://www.eric.ed.gov/

Ryan, K. 1986. *The induction of new teachers*. Bloomington, IN: Phi Delta Kappa Educational Foundation.

Samuelowicz, K., and J.D. Bain. 1992. Conceptions of teaching held by academic teachers. *Higher Education* 24, no. 1: 93–111.

Saroyan, A., J. Dagenais, and Y. Zhou. 2009. Graduate students' conceptions of university teaching and learning: Formation for change. *Instructional Science* 37, no. 6: 579–600.

Shannon, D.M., D.J. Twale, and M.S. Moore. 1998. TA teaching effectiveness: The impact of training and teaching experience. *The Journal of Higher Education* 69, no. 4: 440–66.

Simmons, P.E., A. Emory, T. Carter, T. Coker, B. Finnegan, D. Crockett, L. Richardson, et al. 1999. Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching* 36: 930–54.

Staton, A.Q., and A.L. Darling. 1989. Socialization of teaching assistants. In *Teaching assistant training in the 1990s*, ed. J.D. Nyquist, R.D. Abbott and D.H. Wulff, 15–22. San Francisco: Jossey-Bass.

Sweitzer, V.B. 2009. Towards a theory of doctoral student professional identity development. *The Journal of Higher Education* 80, no. 1: 1–33.

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Tanner, K., and D. Allen. 2006. Approaches to biology teaching and learning: on integrating pedagogical training into the graduate experiences of future science faculty. *CBE Life Sciences Education* 5, no. 1: 1–6.

Timmerman, B., D. Feldon, M. Maher, D. Strickland, and J. Gilmore. 2011. Performance-based assessment of graduate student research skills: Timing, trajectory, and potential thresholds. *Studies in Higher Education* 38, no. 5: 693–710.

Volkmann, M.J., and M. Zgagacz. 2004. Learning to teach physics through inquiry: The lived experience of a graduate teaching assistant. *Journal of Research in Science Teaching* 41, no. 6: 584–602.

Weidman, J.C., D.J. Twale, and E.L. Stein. 2001. Socialization of graduate and professional students in higher education—A perilous passage? ASHE-ERIC Higher Education Report No. 28, no. 3. Washington, DC: The George Washington University, School of Education and Human Development.

Windschitl, M. 2000. Pre-service science teachers and the independent inquiry experience. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA. http://www.eric.ed.gov/

Windschitl, M. 2003. Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education* 87: 112–43.

Yilmaz, K. 2008. Social studies teachers' views of learner-centered instruction. *European Journal of Teacher Education* 31, no. 1: 35–53.

Young, S.L., and A.M. Bippus. 2008. Assessment of graduate teaching assistant (GTA) training: A case study of a training program and its impact on GTAs. *Communication Teacher* 22, no. 4: 116–29.

Zuljan, M.V. 2007. Students conceptions of knowledge, the role of the teacher and the learner as important factors in a didactic school reform. *Educational Studies* 33, no. 1: 29–40.

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