Exploring Links Between Beginning UTeachers' Beliefs and Observed Classroom Practices

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ABSTRACT: Facilitating the transition of STEM teachers into the teaching profession represents an important challenge in teacher education. We argue that it is those aspects of excellent teaching that beginning teachers believe to be important that may be the central foci for teacher preparation. In the context of the nationally replicated UTeach program, we explore how beginning UTeacher's beliefs about important instructional approaches (Study 1) relate to observed classroom practices (Study 2). UTeachers valued classroom practices such as: designing engaging, inquiry-based activities in real-world contexts; responding flexibly to student needs by modifying instruction, differentiation, and using questioning strategies; and effectively communicating content. However, UTeachers showed limited mastery of some practices—they were successful at designing engaging activities but struggled with in-the-moment teaching behaviors such as higher-level questioning and modifications. We also found that while UTeachers reported valuing their content knowledge, they sometimes had difficulty effectively translating their content expertise into a K–12 teaching context.

Obtaining high-quality teachers, particularly for STEM disciplines (science, technology, engineering, mathematics), has been described as a national priority in the United States (Augustine 2005). Especially in underresourced schools, too many students are being taught by underqualified teachers in the STEM disciplines (Darling-Hammond & Sykes 2003). And despite the fact that technology (among other innovations) has altered the educational landscape by transforming the possibilities for instructional practices and student interactions, the critical value and impact that excellent classroom teachers have on student learning increasingly is recognized (Rivkin, Hanushek, & Kain 2005; Rowan, Correnti, & Miller 2002). At least one agent of educational reform continues to focus on improving the teachers sent into the classroom.

The goal of filling classrooms with excellent STEM educators needs to be informed by research on how best to facilitate the teacher preparation process and ease the transition into teaching. We argue that it is the beliefs of beginning STEM teachers about excellent instruction to which educators, researchers, and policymakers should attend, rather than focusing solely on expert opinions. Those practices that novice teachers espouse to be particularly useful for their teaching are worth considering as important for teacher education programs. From two samples of novice teachers (less than three years of experience) who graduated from a nationally replicated STEM teacher preparation program, the UTeach program at the University of Texas at Austin, we explore how links between their beliefs about success in teaching, the UTeach framework for excellence in teaching, and their observed classroom practices contribute to our knowledge of STEM teacher preparation. In particular, this manuscript addresses: to what degree are beginning UTeachers' self-reports about the knowledge and instructional strategies that were influential to their teaching (Study 1) aligned with the instructional strategies observed in beginning UTeachers' classrooms (Study 2). First, we describe the UTeach program, both its history and its philosophy, and then discuss extant literature about novice teachers and make a case to value the perspectives of beginning teachers as a reflection on teacher preparation. Next, we present a theoretical framework for the discussion and provide results from two studies of beginning UTeachers. We conclude by considering the implications of our findings for STEM teacher preparation. In particular, with regard to the challenges and changes that face STEM teacher preparation, we focus on findings that relate to designing inquiry-based lessons, modifying instruction in the moment, and identifying content knowledge that impacts the work of teaching.

Background

The University of Texas at Austin pioneered the undergraduate UTeach program to prepare secondary mathematics, science, and computer science teachers. The program "emerged from the conviction that deep content mastery is essential for excellent teaching, but it is not enough" (UTeach Institute 2007, p. 2). Students in the program are required to major in their content area in addition to completing a sequence of content-specific education courses designed to prepare them for secondary STEM education. An essential thread in the program is the incorporation of early classroom field experiences, which become progressively more involved throughout the university experience (for more information, see UTeach Institute 2007).

The UTeach program began gaining national attention in part because of the high retention rate of its graduates in the teaching profession. UTeach has an 80 percent retention rate of teachers five years after graduation (Marder & Abraham 2009) compared to a national norm of 65 percent (computations based on SASS 2009). The program has expanded to thirty-four different institutions around the United States. Program replication in teacher education at such a large scale is rare (if it has happened at all); it speaks to the program's foundational strengths that such a broad spectrum of universities would be interested. Among other characteristics found through research to be effective in teacher education programs (Sowder 2007), the UTeach program maintains a strong collaborative effort among different faculty at the college level; emphasizes deep content knowledge; models effective teaching at the university level; encourages reflective inquiry; integrates theory, research, and practice; and connects content and methods courses through field experiences. President Obama has mentioned the program as a model for STEM teacher preparation (Randall 2010); the National Math and Science Initiative promoted and facilitated its national expansion.

Despite the expansion, links between beliefs about excellence in teaching and actual classroom practices of graduates from the UTeach program have been understudied, as have the properties of the program that may facilitate teacher development. In this chapter, we seek to investigate the beliefs and practices of beginning UTeach graduates as a reflection on designing STEM teacher education. We examine how their beliefs and practices are aligned or misaligned and how these relationships might inform important topics to focus on in preservice STEM teacher education.

Teacher Preparation in STEM Disciplines

A common theme among teacher education programs is a desire to produce confident and informed beginning teachers that teach according to the field's understanding of good instruction (Brown & Borko 1992). According to Zaslavsky (2009), "the 'content' related to [teachers'] learning involves beliefs, knowledge, and practice as well as some meta-cognitive skills, such as . . . reflection" (p. 105). Thus, STEM content and pedagogical content knowledge, beliefs, and specific practices constitute some of the important domains regarding teacher development. For example, Ball and colleagues (Ball & Bass 2000; Ball, Hill, & Bass 2005; Ball, Thames, & Phelps 2008), among others, have worked toward further conceptualizing the mathematical and pedagogical content knowledge for teachers in their Mathematical Knowledge for Teaching (MKT) framework. This framework is also being discussed as potentially useful for science education (e.g., Bloom & Quebec-Fuentes forthcoming). Additional work by Ball et al. (e.g., Ball & Forzani 2009; Teaching Works 2012) identifies High Leverage Mathematical Practices (e.g., making content explicit through explanation, modeling, representations, and examples), which communicate certain beliefs and practices that are important to the work of teaching.

While all of these ideas help inform some of the necessary knowledge, beliefs, experiences, and practices that STEM educators need to develop, the question still remains as to whether these may be best addressed within teacher preparation programs like UTeach, or continuing professional development. Although teacher education programs can be seen as the sole source of preparation for the classroom, increasingly, scholars have begun to conclude that preparing teachers "in four short years . . . is not possible" (Sowder 2007, p. 213); teachers should and must continue to develop throughout their careers. The recognition of the critical role that both teacher preparation and professional development play in the growth of excellent STEM educators begs the question: Which knowledge, beliefs, experiences, and practices should teacher education programs focus on developing? In this chapter, we will use the perspectives of beginning teachers as a means to begin addressing this important question.

Beginning Teacher Beliefs and Practices

While the research on teacher education continues to add to our understanding of preparing and developing excellent educators, discerning the resultant impact on the educational philosophies and practices of beginning teachers remains somewhat more elusive. Although teacher preparation programs like UTeach aim to create coursework and fieldwork that communicate knowledge of effective teaching strategies and practices, infiltrating actual classroom practices and beginning teachers' beliefs about teaching can be challenging.

Brown and Borko (1992) summarize studies from the National Center for Research on Teacher Education and the Learning to Teach Mathematics Project, both of which report the difficulties of altering novice teachers' instruction to align with more reform-based teaching approaches through university courses. Frykholm (1999) also notes that despite a commitment on the part of the mathematics education community toward standards-based reform, a mismatch between beginning teachers' knowledge of standards and their teaching practice exists. So regardless of an attempt to clarify explicitly through standards what teachers and students should do in STEM classrooms, teacher education programs do not always help prospective teachers take this knowledge into classroom practice. Indeed, many studies have concluded that teachers are of the mind-set that experience teaching in the classroom as a full-time teacher, as opposed to teacher education, is the real source of learning to teach (e.g., Wilson, Cooney, & Stinson 2005).

In addition, teachers' beliefs are notoriously difficult to change; yet, according to some researchers (e.g., Pajares 1992; Thompson 1992), beliefs may impact teaching practices more so than knowledge. Compounding the difficulties faced by teacher education programs, teachers may have apparent inconsistencies between their espoused beliefs and practices (Raymond 1997) or may be unaware of their own beliefs (Furinghetti & Pehkonen 2002). It is no surprise, then, that teacher education programs have noted the difficulties in altering beginning teachers' instructional beliefs. Thompson (1992) reported that teachers do not frequently change their fundamental beliefs, often assimilating any new ideas to fit within their existing belief structure. And while some researchers have reported ways that teacher education has impacted beginning teachers' espoused beliefs (e.g., Fennema, Carpenter, Franke, Levi, Jacobs, & Empson 1996; Hart 2002), Perrin-Glorian, Deblois, and Robert (2008) reflect that even changing teachers' beliefs during the course of a preparation program has not necessarily brought about changes in teaching practices. It is also important to acknowledge that the school context itself can place pressure on teachers and their instructional choices—thus, although teachers may believe in the excellence of particular teaching approaches, they may perceive limited opportunities to use them in practice. All of these issues point to the importance of examining the interaction of beliefs and practices in beginning teachers.

The Choice of Beginning Teachers

The challenges that beginning teachers face in overcoming the transition to the realities of the teaching profession, while also becoming excellent STEM educators, are many. Yet focusing solely on changing teachers' beliefs may not translate to the desired change in teaching practices, and focusing only on changing teaching practices may be trumped by preconceived beliefs. Beliefs and practices must change together. Thus, to understand the impact of STEM teacher education on beginning teachers, we look at the alignment between the philosophies of a teacher education program, the actual practices of beginning graduates, and the beliefs that graduates have about what helps create excellence in STEM teaching (see Figure 1).

While teacher education can be an important factor in preparing teachers for the profession (evident throughout this special issue on STEM teacher

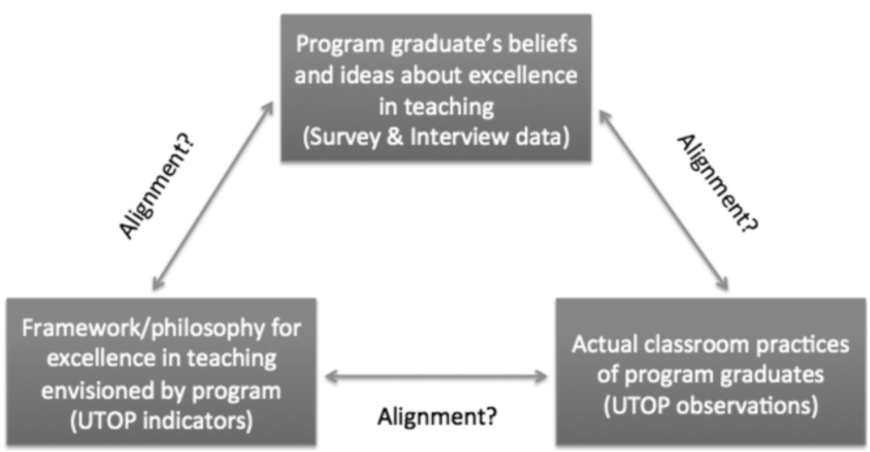

Figure 1. Theoretical framework.

education), programs cannot (and should not) teach everything a teacher needs to know before entering the profession. Similar to the transition that one faces when moving to a new city (in which preparation can help make the transition smoother, but also where some aspects may be best understood upon arrival), specific aspects of the teaching profession may be learned better during the transition to teaching—not prior. While experts are undoubtedly a great source of such wisdom, we argue that through the lens of novice teachers, those recently having dealt with the transition, an equally important perspective on teacher education is gained that may inform the distribution between teacher education and professional development.

Novice teachers have high expectations and accountability measures placed on them—by others and themselves—coupled with little time and few resources, which cause numerous demands that compete for their time and attention. Due to the demands on a novice teacher's time during this transition, what beginning teachers believe to be important for good teaching influences what they choose to enact and attend to in the classroom. From their notions of excellent teaching, we gain perspective on those aspects of the profession that are valued by novice teachers and that influence their practices and instructional choices. We argue that it is precisely these aspects valued by beginning teachers that should be addressed in teacher education; not attending to them only sets up potential issues during the transition to the profession. Indeed, supporting beginning teachers in areas that increase their sense of accomplishment in teaching has the potential to improve teacher empowerment and satisfaction, teacher retention in the profession, and the effectiveness of preparation programs.

In this chapter, we detail results from two studies about beginning teachers who graduated from the nationally replicated UTeach program (UTeachers) as a means to reflect on STEM teacher education. Specifically, the research question we address is: To what degree are beginning UTeachers' reports about the knowledge and instructional strategies that were influential to their teaching (Study 1) aligned with the instructional strategies observed in beginning UTeachers' classrooms (Study 2)? Through the perspective of these transitioning teachers, we discuss how alignment and misalignment between novice teachers' reports and teaching practices can inform the challenges and changes that face STEM teacher education.

Methodology

Study 1. In the first study (conducted in May 2010), UTeachers with between one and two years of teaching experience participated in a mixed methodology study to uncover their beliefs about what was important for successful teaching during the transition to the profession. Thirty-seven mathematics teachers participated, a 75 percent response rate. A survey instrument was designed to gather information about the beginning UTeachers' beliefs and reported classroom practices. Literature and local experts helped form a framework for the instrument design; each question was constructed to measure specific variables (appendix A). The survey went through various stages of development, including a pilot study (n = 10) to verify content validity and reliability (Cronbach's alpha, a~0.7). Based on the UTeachers' survey responses, those attributes most commonly agreed upon by the entire sample (statistically different from responding "neutral" on the Likert scale) were selected in the analysis. These survey items provided attributes that the beginning UTeachers, collectively, reported as important to their teaching.

An intentional sample of survey participants (n = 8) was then chosen for interviews based on three criteria: nomination from a consortium of teacher educators as the top of his/her graduating class; a minimum 3.0 GPA in undergraduate content courses; and prior experience in a leadership position. The goal was to identify strong candidates that represented top graduates from the UTeach program, forming a purposeful sample of information-rich cases whose insights into beginning excellence in teaching were of particular interest. The selected UTeachers participated in a one-hour semistructured interview intended to elaborate on those aspects that they found to be particularly important for their successful transition to teaching. The interviews were transcribed and analyzed through the constant comparative method (Strauss & Corbin 1990), resulting in identification of important themes both between and within cases. The qualitative data expands upon and elucidates the quantitative results, providing additional thoughts and descriptive examples from beginning UTeachers' perspectives.

Study 2. In the second study, twenty-one UTeach graduates with between zero and three years of teaching experience were observed in their classrooms. The observations (lasting between fifty and ninety minutes) occurred over five semesters (Spring 2007 to Spring 2009), and each teacher was observed between one and five times for a total of fifty-two observations. The UTeachers taught mathematics, science, or computer science in nine different high schools and four middle schools in two districts. The districts (one urban, one rural) were chosen for their proximity to the researchers, and teachers voluntarily agreed to be part of the study—a convenience sample. There were two trained observers present (blind to the preparation program—non-UTeach graduates were included in the larger study), one with a background in mathematics and one in science. Observers tried to observe each teacher at least once (no more than twice) per semester.

The observers used the UTeach Observation Protocol (UTOP; Walkington et al. 2011), developed by UTeach faculty to be in accord with key UTeach philosophies for excellent STEM teaching. The UTOP includes thirty-two indicators (teaching behaviors) organized into four sections, which represent the "Framework/Philosophy for Excellence in Teaching Envisioned by the Program" in the theoretical framework in Figure 1;

each indicator is rated on a one-to-five Likert scale, with Don't Know/Not Applicable options. Each of the four sections—Classroom Environment, Lesson Structure, Implementation, and STEM Content—concludes with a section synthesis rating on a one-to-five scale. The UTOP includes a fifteen-to thirty-minute postlesson interview conducted with the teachers to discuss the context of the lesson and what occurred.

Observers obtained an average-weighted kappa of 0.41 on the thirty-two indicators, which corresponds to moderate agreement; on the synthesis ratings, the weighted kappa was 0.63, substantial agreement (Landis & Koch 1977). Observers discussed and came to a consensus on all scores after giving independent ratings. Additional analyses of UTOP's reliability, factorial structure, and correlation with teacher value added were conducted in follow-up work; overall, the UTOP is comparable to other widely accepted observation instruments such as the CLASS protocol or Charlotte Danielson's Framework (see Gates Foundation 2012).

Based on the reports from beginning teachers about the attributes they believed to contribute to excellence in STEM teaching (Study 1), the analysis for Study 2 examined the UTOP observations to see whether UTeachers generally demonstrated competency on these behaviors in their classrooms. The evidence was compiled by selecting UTOP indicators that related to each teacher belief. For example, teachers from Study 1 discussed the importance of content knowledge; thus, for Study 2, we selected UTOP indicators that would tap into how a teacher's content knowledge would be evident in their classrooms. Table 1 lists the UTOP indicators that were analyzed. Summary statistics for the indicators were computed; in most cases, a score of 3 is considered adequate. Thus, for the purposes of this analysis, we consider an average score less than 3 to suggest a practice UTeachers are weaker on, while an average score greater than 3 suggests a practice UTeachers are stronger on. Observers also provided two-to-five sentences of supporting evidence for each rating. The supporting evidence was coded using thematic analysis techniques (Braun & Clarke 2006), and themes were refined and compiled into shorter lists using constant comparisons (Glaser & Strauss 1967). Then the incidences of each theme were compared in order to identify the most prevalent themes in the supporting evidence for each indicator.

Findings

Based on the possible alignment between the three-part framework (see appendix B), we primarily focus our findings on aspects that beginning UTeachers' believed to be important for excellent teaching, some of which were observed in their practices and others of which were not. Three primary findings will be presented about UTeachers' beliefs and practices that relate to: 1) designing lessons that are inquiry based, use real-world connections,

Table 1. UTOP Indicators

Belief	*Corresponding UTOP Indicators*
Designing lessons that are (1) inquiry based, (2) use real-world connections, and (3) involve active student participation	**3.1** The instructional strategies enhanced student abilities to engage with or explore important concepts in mathematics or science. **4.7** Appropriate connections were made to other areas of mathematics or science, to other disciplines, or to real-world contexts. **1.1** The classroom environment encouraged students to generate ideas, questions, conjectures, and/or propositions that reflected engagement or exploration with important mathematics and science content and concepts.
Modifying instruction by (1) using questioning strategies, (2) responding flexibly to student needs, and (3) attending to specific classroom contexts	**3.3** The teacher's questioning strategies developed student conceptual understanding of important mathematics or science content (e.g., emphasizing higher-order questions, appropriately using "wait time," identifying prior conceptions and misconceptions). **3.7** The lesson was modified as needed because the teacher was able to "read" the students' level of understanding through probing questions or other assessments of student understanding. **1.8** The classroom environment established by the teacher reflected attention to issues of access, equity, and diversity for students (e.g., cooperative learning, language-appropriate strategies and materials).
Content knowledge in the work of teaching	**4.2** The significance of the math and science content, including how it fits into the "big picture" of the discipline, was made explicit to the students. **4.3** Content delivered through direct instruction by the teacher is consistent with deep knowledge and fluidity with mathematics or science concepts of the lesson. **4.5** The teacher's depth of subject-matter knowledge was evidenced throughout the nondirect instruction (i.e., fluid use of examples, questioning strategies to guide student learning, discussions and explanations of concepts, etc.).

and involve active student participation; 2) modifying instruction by using questioning strategies, responding flexibly to student needs, and attending to classroom contexts; and 3) the need for specific content knowledge in the work of teaching.

Designing Lessons

In Study 1, the beginning UTeachers were adamant about how designing lessons that were inquiry based with real-world connections and actively involved students were important for excellent STEM teaching. Responses from the entire population of beginning UTeachers on the Active Student Instruction survey item ("You facilitate classroom discussions where students actively participate in the learning process as opposed to primarily teacher-presented information") was statistically significant ($p < .05$), compared to a response of Neutral, indicating that the UTeachers believed this was important to their instruction. During interviews, the UTeachers expanded on the importance: "I've found what works best is setting up procedures and letting the kids be in control of their learning. And that is hard to do . . . And then if you set it up right, it should run itself" (Ali). Other participants elaborated on the importance of using real-world examples to make mathematics meaningful; Julia, for example, discussed using a Ferris wheel to introduce periodic functions, commenting that "and then they don't even realize it but they're exploring all the main features of periodic functions." Throughout the interviews, UTeachers recognized the influence of the UTeach program on their pedagogical ideas about designing instruction, particularly how the 5-E lesson model[1] saturated their planning ("without even thinking about it, when I'm planning how am I going to structure my lesson, I think of . . . a 5-E way") (Elisa). Indeed, the notion of using an inquiry-based instructional approach to designing lessons, while new to most UTeachers, was influential: "And I think that's a big backbone of UTeach. The idea of if you understand it, if you discover it, you'll remember it, you'll retain it" (Sarah). The findings from the first study provide documentation about the beliefs of beginning UTeachers regarding how designing lessons that are inquiry based, connected to the real world, and actively involve students are important for good instruction.

In Study 2, beginning UTeachers also demonstrated through their observed practices that they were able to implement this kind of instruction. In particular, evidence from the classroom observations shows how UTeachers taught inquiry-based lessons, used real-world connections, and structured lessons to support active student participation. Indicator 3.1 on the UTOP reads "The instructional strategies enhanced student abilities to engage with or explore important concepts in mathematics or science," and UTeachers scored an average of 3.3 ($\sigma = 1.5$). Of the fifty-two observations, forty-three had clear-enough evidence to elaborate on the coding. The emergent themes from the observers' descriptions revealed that 33 percent of these observations involved elements of discovery learning or exploration, 26 percent involved students constructing justifications or predictions for their work and/or engaging in practices of argumentation and classroom discussion, 26 percent involved laboratory investigations or experiments, and 21 percent involved true or project-based instruction. A quote from the supporting evidence in one of the project-based lessons was: "This project was situated in the real-world context of making math- and science-related decisions about a band's performance at South by Southwest. Students had to create a merchandize plan using inequalities, design the stage using geometry, set up a lighting system using circuits and light bulb efficiency, and much more." These themes compare to 33 percent of observations that showcased characteristics of more traditional instruction. Given that we conceptualize a teacher skilled in inquiry as using a combination of reform and traditional instruction, instructional strategies to engage students were prevalent.

Designing lessons connected to the real world was also supported by data from the UTOP indicator: "Appropriate connections were made to other areas of mathematics or science, to other disciplines, or to real-world contexts." The average score on this indicator was 3.2 ($\sigma = 1.3$). Of the fifty-two observations, forty-five had sufficient evidence to code. UTeachers did not make real-world connections in 20 percent of the observations. Their use of real-world contexts was evident through teachers using story/word problems in 20 percent of observations, giving real-world illustration of concepts in 27 percent, providing real-world motivation for the content in 11 percent of observations, using laboratory activities situated within real-world contexts in 9 percent, and incorporating project-based activities situated in and arising from real-world contexts in 13 percent of observations. Again, given that these connections may not be appropriate for all lessons, this was a relatively prevalent teaching behavior. One observer wrote, "The lesson allowed students to engage with this content—the teacher used demonstrations of throwing and rolling a ball he had with him, and also showed a video of a motorcycle acting as a projectile. He used interesting real-life examples, and called for student input often when setting up the examples."

Finally, data from the UTOP indicator, "the classroom environment encouraged students to generate ideas, questions, conjectures, and/or propositions that reflected engagement or exploration with important mathematics and science content and concepts," revealed how UTeachers designed engaging lessons that actively involved students. The mean score on this indicator was 3.2 ($\sigma = 1.4$). Of the fifty-two observations, forty-five had evidence informative enough to code. In 29 percent of these classrooms, the students were described as generally being passive or off task. However, in the remaining observations, there were various examples of lessons in which students were encouraged to generate ideas, strategies, predictions, justifications, explanations, and questions. Thus, UTeachers showed evidence of designing inquiry-based lessons with real-world connections that involved active student participation in observations of their practice.

Modifying Instruction

In Study 1, beginning UTeachers valued the ability to modify their instruction by responding flexibly to student needs, attending to specific classroom contexts, and using questioning strategies to support intellectual engagement. While similar to the idea of differentiation, the discussion during UTeachers' interviews included more than just modifying instruction to specific groups of students. These UTeachers recognized that "what [the teacher] think[s] is engaging and exciting is not necessarily what, you know, a 62 percent Hispanic population thinks is engaging" (Ali). Modifying instruction to attend to specific classroom contexts was valued by the collective group of beginning UTeachers; responses to the Contextualize survey item ("You pay attention to the particular class of students that you teach while planning lessons, incorporating ideas that would be of specific interest to them") were significant ($p < .05$). One UTeacher expands on the adjustments she had to make for her classroom context:

> It was just a different environment. I think that was, most of my students were Hispanic and African American . . . Just their culture, compared to my culture. It just was eye-opening too, because it was just very different. And they would just talk about different things . . . And kind of it was, just, to learn more about how I teach in, and how to adjust my teaching. (Sarah)

The beginning UTeachers also indicated that being flexible in their instruction and adjusting to students' needs was important to their teaching. UTeachers' responses to the Flexible/Adaptive survey item ("You are flexible and adaptive in your teaching—comfortable making decisions at the last moment based on what has actually happened versus what was planned to have happened") were significant ($p < .05$), indicating that they felt capable of adapting to specific students. Interviewed participants expanded on these ideas:

> If I'm talking to someone, and I'm trying to help them . . . if I had that glazed look, and the staring right back at me, I knew I was doing something wrong. I needed to change it. (Rebecca)

In terms of modifying instruction, beginning UTeachers also believed that using a variety of questioning strategies was important. UTeachers overall indicated that they elected to use questioning strategies to probe thinking instead of directly telling students the answers ($p < .05$, Questioning Strategies item: "You directly give answers when students have questions, as opposed to giving hints aimed towards helping students solve the problem themselves"). During her interview, Abby mentioned that "now the questioning techniques that are embedded in my bag of tricks doesn't ever let a day turn into a straight lecture. I'm constantly interacting with these kids, and checking for understanding." Overall, the findings indicate that beginning UTeachers placed importance on modifying their instruction for students through responding flexibly, attending to specific classroom contexts, and using questioning strategies.

While the beginning UTeachers believed these were important for excellence in their STEM teaching, in Study 2 they demonstrated through their observed practices some weaknesses in enacting this kind of instruction. In terms of responding flexibly, the UTOP indicator, "The lesson was modified as needed because the teacher was able to 'read' the students' level of understanding through probing questions or other assessments of student understanding," had an average score of 2.7 ($\sigma = 1.3$), which indicates relatively weak practice. Of the fifty-two observations, forty-four had evidence that was informative enough to code—evidence for this indicator also took into account teacher reflections during the postinterview in which they discussed how they had modified instruction. In 25 percent of the observations, there were no teacher-cited modifications, in 7 percent there were inappropriate modifications, and in 16 percent there were no modifications with explicit reference to missed opportunities to modify. When the teacher did modify instruction, it often only involved providing more time (25 percent of observations) or additional guidance (16 percent of observations). Overall, modifications did not seem to be a skill these beginning UTeachers had mastered in practice. One observer wrote: "The teacher did not make modifications to make sure the students understood the material. When students did not understand, she would just say, 'You know where you can find the answer to this—the reading,' rather than ask them probing questions."

In terms of attending to specific classroom contexts, none of the indicators on the UTOP capture this behavior in precisely the way UTeachers described it, but the closest indicator is, "The classroom environment established by the teacher reflected attention to issues of access, equity, and diversity for students (e.g., cooperative learning, language-appropriate strategies and materials)." UTeachers scored relatively high on this indicator (average of 3.3, $\sigma = 1.2$), which relates primarily to differentiation. The coding of the forty-one relevant observations revealed that some UTeachers tended to successfully use cooperative learning (37 percent of observations), multiple media (15 percent of observations), promote an open/relaxed environment (17 percent of observations), and make appropriate modifications for struggling students, special education students, and those who had language issues (29 percent of observations).

Finally, in terms of using questioning strategies to promote intellectual engagement, UTeachers were again relatively weak on this behavior during the observations. The indicator, "The teacher's questioning strategies developed student conceptual understanding of important mathematics or science content (e.g., emphasizing higher-order questions)," on the UTOP was examined, and the beginning UTeachers had an average score of 2.6 ($\sigma = 1.2$). Here, forty-six of the observations had sufficient evidence to code. In 50 percent of the observations, the teacher asked no higher-level questions, focused on fact-based questions, and/or used little wait time. One observer wrote, "When assisting the students one-on-one or working with the students in the whole-class environment, the teacher focused on instructing the students rather than having them discover concepts through questioning. All of the questioning the teacher did do was very simple 'fill-in-the-blank' type questioning." While 30 percent of observations revealed some aspects of effective questioning, such as asking some higher-order questions and/or using questioning to provide scaffolding, there were missed opportunities: only 20 percent of the observations were coded as using consistently strong questioning techniques. Thus, UTeachers were relatively weak in enacting practices relating to questioning techniques and modifying instruction in the moment, but they demonstrated more structured types of differentiation to promote access.

Content Knowledge

In Study 1, the beginning UTeachers emphasized the importance of their own content knowledge as critical to their instruction. Abby discussed how "they can smell it when they know you don't know a concept very well . . . If you're not prepared, if you walk in and try to wing it and you're missing just a little hole, you'll have that kid that'll find it and that's for sure. So I think a strong content is very important." As a whole, beginning UTeachers felt prepared in their content area. The Math Confidence and Problem-Solver survey items ("You feel confident in your mathematical knowledge to answer student questions that come up during class"; and "You are a confident problem solver, able to solve novel problems") were statistically significant ($p < .05$): all UTeachers either agreed or strongly agreed with the two statements. While there was some discord between interviewed participants about the utility and influence of upper-level content courses on their teaching practices, most ended up with a position exemplified by Chris's statement: "I've seen [my content] at a much higher level than we're going to teach it obviously, but it gives me background knowledge and confidence to where I can teach it." Indeed, strong content knowledge was considered crucial by UTeachers for excellent teaching, because "you have to understand the math in order to come up with activities, unless you just want random stuff. But if you want more in-depth, connecting stuff, you need to have the math content. You need to understand how things connect before kids are going to ever understand it" (Erin). Beginning UTeachers valued the importance of strong content during their transition to teaching, stressing increased confidence in their instruction and more authority responding to questions.

While the results from Study 1 indicate that beginning UTeachers believed strong content was important for successful teaching, observations of their teaching in Study 2 created a divide between two aspects of their content, one of which they were able to achieve while the other proved more difficult to demonstrate. First we examined indicator ratings on two measures of fluent content delivery, "Content delivered through direct instruction by the teacher is consistent with deep knowledge and fluidity with mathematics or science concepts of the lesson," and "The teacher's depth of subject-matter knowledge was evidenced throughout the nondirect instruction (i.e., fluid use of examples, questioning strategies to guide student learning, discussions and explanations of concepts, etc.)." The supporting evidence for these two indicators was combined into a single narrative for each observation, as there was often overlap or lessons that had little direct instruction. The average score across these two indicators was 3.1 ($\sigma = 1.2$), and of the fifty-two observations, forty-four had evidence informative enough to code. In 36 percent of the observations, the observer noted poor content-related scaffolding and/or questioning to guide student learning, and 23 percent included little or no generation of examples to guide conceptual understanding. However, teachers gave fluid explanations in 32 percent of observations, used questioning to successfully guide conceptual development in 34 percent of observations, and generated important content-related examples in 21 percent of observations. One observer wrote, "The teacher used questioning extensively during the lesson, and this questioning reflected his content knowledge on ratios as well as his understanding of how to guide students from their misconceptions. The teacher explained concepts, such as why a fraction line should be horizontal, but more often used his content knowledge to guide students' explanations in the proper direction." Overall, UTeachers seemed to be relatively strong at communicating fluid content; there were some, however, that struggled. While there were very few examples of incorrect content being communicated (one observation) or the teacher providing unclear explanations (11 percent of observations), some UTeachers missed opportunities to make the content maximally understandable and accessible to students.

We also examined evidence from the indicator "The significance of the math and science content, including how it fits into the 'big picture' of the discipline, was made explicit to the students." The evidence included a postobservation interview question in which the teacher was asked how the big picture was made explicit during the lesson. The average score on this indicator was 2.4 ($\sigma = 1.5$)—seven of the fifty-two observations were omitted because this indicator was a late addition to the UTOP. An additional seven had uninformative supporting evidence, for a total of thirty-eight remaining observations. Of these, in 24 percent of observations, the teacher reported not making any big-picture connections but intended to at a later date, while in 11 percent of observations teachers discussed how they had made this connection previously. In an additional 21 percent of observations, there was simply no connection to the big picture, past, present, or future. During 11 percent of observations there was mention of making the big picture explicit by connecting to standards, standardized tests, or standardized curricula, while the most common means of connecting the content to the big picture was through making real-life connections (24 percent of observations). One quote from supporting evidence was, "The teacher said that solving systems of equations was an important skill for students to have to solve any problem where more than one relationship was involved. The teacher said that she did not go over this aspect of the 'big picture' with her students, but that she did tell them it was on the TAKS test, which is the 'big picture' for them." Finally, five observations included big-picture links in which different ideas in a conceptual domain were strung together or connected to prior and future learning by the teacher. However, overall, significant connections to the big picture were rarely seen, and many of the beginning UTeachers seemed to have difficulty making these connections. One UTeacher admitted that she herself did not yet see the big picture of the content she was teaching, so she could not hope to make it explicit to students yet.

Discussion

The findings of these two studies indicate some reflections on teacher education from the perspective of beginning STEM teachers, which were used as a lens to help specify important aspects on which teacher education could focus. In the following section, we discuss the results for each of the three relevant findings (designing lessons, modifying instruction, and content knowledge) and the respective implications for teacher education. The discussion illuminates strengths of the teachers based on their observed ability to enact certain teaching attributes, detailing further some potential ways the UTeach program may have facilitated impacting teachers' beliefs and practices; in addition, we discuss some places of apparent disconnect between the beginning UTeachers' beliefs and practices, informing specific ways teacher education programs may be able to better meet the needs of novice teachers during the transition.

Impact on Beliefs *and* Practices

Designing lessons. Beginning UTeachers valued designing lessons and instruction that were inquiry based, connected to the real world, and actively involved students; they also were competent to enact those lessons in the classroom. Preparing teachers to simultaneously believe in and be capable of designing lessons consistent with these ideals is both a suitable goal and a good use of time and resources during teacher education: it is one of the attributes beginning teachers reported to be particularly helpful during the transition to education.

Teacher preparation programs frequently try to achieve this result: impacting both the beliefs and practices of graduates. Yet research indicates that doing both has not necessarily been easy to achieve for teacher education programs, particularly toward reform-based practices in STEM education (e.g., Brown & Borko 1992; Frykholm 1999). So while reform-oriented instruction is often a goal of STEM teacher education, particularly planning inquiry-based lessons, the findings from this study suggest that impacting the beliefs and practices of beginning teachers is also attainable. Based on the interviews with participants from Study 1, one likely explanation is related to modeling this type of instruction at the university level; Sowder (2007) mentions this as one attribute of effective teacher education programs based on a synthesis of research. Many UTeachers had not been introduced to reform-based pedagogy in STEM education prior to the UTeach program, yet a number of participants echoed Chris's sentiment: "I think the UTeach structure completely changed my vision of what it's like to be a teacher." During the interviews, one of the reasons that continued to resurface as an explanation for the impact of the UTeach program related to how instructors modeled this type of reform-based instruction:

> It wasn't just here is a bunch of methods. The more, the further I went into the UTeach program, I realized that they were using the methods on us. That we were learning in the ways that they were teaching us to learn. And so I appreciated that and got to see the real impact of inquiry-based learning and the power it can have because I had been taught by so many lecture styles. (Abby)

For teacher education programs, identifying tangible ways to not just talk about reform-based instruction in STEM education but also to model this type of instruction in courses for future teachers may be one key to effecting change in beginning teachers' beliefs and practices.

Content knowledge. Beginning UTeachers valued strong content knowledge as an important attribute that helped with their successful transition to the classroom. Observations of their teaching indicate that these teachers presented content that was accurate and demonstrated fluid content knowledge during instruction. As mentioned previously, strong content knowledge is reinforced throughout the UTeach program. The program's content requirements, which include majoring in a STEM content area, likely helped the beginning UTeachers gain confidence in their content knowledge; however, there were also specific aspects relating to content that the beginning UTeachers did not demonstrate in their lessons. We explore these, and the implications for teacher education, further in the next section.

Impact on Beliefs *but not* Practices

Modifying instruction. Beginning UTeachers reported that attending to student needs through engaging in questioning to elicit intellectual engagement, culturally relevant instruction (Gay 2010; Ladson-Billings 1994), and making in-the-moment modifications accordingly contributed to their feelings of success during their transition to the profession. However, observations revealed that many UTeachers' struggled to aptly modify instruction for their students and engage in higher-level questioning. This disconnect between UTeachers' beliefs and practices provides additional insight into potentially important focal points for teacher education programs. Despite the numerous field experience opportunities during the UTeach program, the relative shortness of the experiences may have limited the beginning UTeachers' ability to effectively modify their instructional practices. Certainly, the act of appropriately modifying instruction is a very complex task, as teachers have to simultaneously and perpetually gather input from students' responses and alter their instructional output accordingly.

Helping teachers work toward being able to modify instruction in meaningful ways could be a candidate for continuing professional development due to its complexity; however, based on the perspectives from beginning UTeachers, identifying ways for teacher education programs to prepare graduates in this aspect may be important. In fact, this result aligns with a growing recognition in the field that the field of education simply does not have the established nomenclature to describe effective teaching practices (e.g., the work on high-leverage practices, Teaching Works 2012). Experts are still working to understand precisely how teachers make decisions in the moment and why they make the choices they do during instruction (e.g., Schoenfeld 2010). Perhaps increased research on understanding the qualities that relate to modifying instruction will translate into effectively preparing novice teachers for the challenges faced during the transition. Teacher education programs could also find ways to promote field experiences that provide an opportunity for novice teachers to practice modifying their instruction in different settings, perhaps by emphasizing the use of formative assessments for making instructional decisions, designing lessons that are contextualized for specific audiences, or self-evaluating videotaped teaching episodes according to an observation protocol (such as the UTOP).

Content knowledge. While beginning UTeachers valued strong content knowledge and demonstrated some components of it during observed lessons, they also seemed to struggle to relate lessons to the overarching big picture. The split findings indicate that while learning STEM content is an important component of teacher education, there are other aspects of content knowledge specific to the profession of teaching that also need to be addressed. While it is not necessary for a mathematics major that intends to become an actuary to be able to explain the significance of extending exponents to include the set of real numbers, the instruction of secondary mathematics teachers likely is improved by such content knowledge. In fact, one of the proposed high-leverage teaching practices (Teaching Works 2012) is making content explicit through explanation. So while future STEM teachers' majoring in their content area may be an effective way of requiring strong content, more work needs to be done to identify some of the big-picture mathematical ideas that impact teachers' classroom instruction. According to Ball et al.'s (2008) framework for Mathematical Knowledge for Teaching, this aspect aligns with their description of Horizon Content Knowledge (HCK), which describes how teachers are aware of the vertical alignment for content areas and set the foundation for more advanced mathematics. Specific to undergraduate mathematics courses, Wasserman and Stockton (2013) suggest ways to research the impact of HCK on teaching. While content knowledge is important for STEM educators, more research needs to be accomplished that informs content requirements during STEM education, balancing the content demands of classroom teachers with the need to know more advanced, discipline-specific content knowledge.

Generalizations and Limitations

Given that the beginning STEM teachers in this study were all from the UTeach program, it is important to consider whether these trends would look similar for beginning STEM teachers in general. Our larger observational study examined both beginning UTeachers and beginning non-UTeachers who were teaching similar subjects at the same schools. Comparisons revealed that non-UTeachers, who had a variety of preparation backgrounds, had similar weaknesses to UTeachers in terms of modifying instruction in the moment, questioning, and connecting content to the big picture. Interestingly, they as a group lacked some of the UTeacher's key strengths—such as designing engaging inquiry lessons and consistently communicating accurate and fluid content. However, graduates from many of the recent reform-oriented preparation programs may appear more similar to UTeachers. In both the current study and our prior work, the strength of our conclusions is limited by both our sample size and the generalizability of the selected samples of beginning teachers. While one comparative study (Wasserman & Ham 2013) indicates that beginning teachers from an alternative certification program had similar beliefs about important instructional practices as the UTeachers, it is not entirely clear whether this would be representative of novice teachers from all preparation backgrounds.

A final issue we wish to raise is the relationship between Study 1 and Study 2—we highlight that these were different samples of UTeachers. So although our results are suggestive and give interesting trends to be followed up on in future work on STEM teacher preparation, these studies and the links we discovered are primarily intended to be exploratory in nature. In current work, the UTOP is being used to continue to observe groups of UTeachers and non-UTeachers, in combination with in-depth interviews about their beliefs about excellent instruction. Ultimately, longitudinal work is needed that follows beginning STEM teachers over time to examine how their beliefs about instruction and their classroom practices evolve as they gain more experience, and how their preparation experiences influence their development.

Conclusion

Using the perspective of beginning teachers, it is evident that teacher preparation programs would serve their prospective teachers well by finding ways to help them: design lessons that are inquiry based, connected to the real world, and actively involve students; modify instruction by responding flexibly to student needs, attending to specific classroom contexts, and using questioning strategies to support intellectual engagement; and learn discipline-specific content knowledge that is related to the work of teaching. Listening to the voices of beginning teachers suggest that these aspects may be a priority for teacher preparation due to the potential benefits for helping teachers feel successful during the transition to the profession; this may, however, involve limiting other emphases in preparation programs.

We briefly note that while classroom management was not presented in this paper, beginning UTeachers did validate its importance. In particular, their discussion of designing inquiry-based lessons was often intertwined with classroom management, indicating that effective inquiry-based lessons promoted a productive learning environment and helped manage disruptions. While we primarily presented the design of lessons in this chapter, this emphasis from beginning UTeachers also inherently connected to classroom management. To discuss some of the possible implications for teacher education, we also mention one example from the UTeach program—an emphasis on the history and philosophy of the sciences—that was rarely professed by beginning UTeachers as knowledge that was critical to effective STEM instruction. We do not argue that such knowledge is unimportant to teaching (likely, it is); however, from the reports of beginning teachers, it may be that such knowledge is more suited for being learned during continuing professional development. Alternately, how this topic is taught in preservice education could be revamped such that it has a larger impact on teacher beliefs. While this is only one example, many other possibilities exist for modifying teacher education to serve the needs of beginning teachers who may benefit more from an increased focus on those aspects of instruction and practice that will likely be considered important and influential by them.

Through exploring the alignment between beginning UTeachers' beliefs and practices (observed according to the UTOP) from the findings of two studies, we have reported on some challenges and changes that face STEM teacher preparation. In order to support teachers through their transition to teaching, it is important for teacher education programs to find ways to promote how to design and implement lessons that are inquiry based (the modeling of such instruction during the program may be one compelling factor), incorporate modifying lessons according to various classroom contexts, and specify and teach STEM content knowledge that impacts the work of teaching. By paying attention to beginning teachers, teacher educators and teacher education programs can be tailored in ways that "pay it forward" to students by improving the STEM instruction of novice teachers. TEP

Appendix A

Variables for Study 1 Survey. Survey Items Listed by Study Variable

Item #	*Study Variable*
1a	Assessments for Differentiation
1b	Engaging Lessons
1c	Collaboration With Colleagues
1d	Good Rapport
1e	Positive Feedback
1f	Good Student Test Scores
1g	Good Classroom Learning Environment
1h	Growing Professionally
2	Engaging Mathematical Activities
3	Technology
4	Collaborate
5	Reflect
6	Differentiation
7	Teacher-Centered Instruction
8	Active Student Participation
9	Heuristic Hints/Questioning Strategies
10	Contextualize
11	Confident in Mathematics
12	Depth and Breadth of Mathematics
13	Problem Solver
14	Knowledge of State Standards
15	Classroom Management
16	Efficacy
17	Belief in All Students
18	Grow Professionally
19	Organized
20	Enthusiasm
21	Flexible/Adaptable
22	Assess Lesson Objectives
23	Previous Experience
24	Resources
25	Job Satisfaction
26	UTeach
27	Pre-UTeach
28	Post-UTeach
29	Model of Mathematics Teaching
30	Mathematics Knowledge
31	Achieving Success

Survey Items Listed by Strand

Strand	*Item #*	*Variable*
Knowledge for Mathematical Tasks	2	Engaging Mathematical Activities
	11	Confident in Mathematics
	12	Depth and Breadth of Mathematics
	13	Problem Solver
	14	Knowledge of State Standards
	30	Mathematics Knowledge
Role in Discourse	7	Teacher-Centered Instruction
	8	Active Student Participation
	9	Heuristic Hints/Questioning Strategies
	21	Flexible/Adaptable
	29	Model of Mathematics Teaching
Learning Environment	1b	Engaging Lessons
	1d	Good Rapport
	1g	Good Classroom Learning Environment
	15	Classroom Management
	17	Belief in All Students
Tools to Enhance Discourse	3	Technology
	6	Differentiation
	9	Heuristic Hints/Questioning Strategies
	10	Contextualize
	24	Resources
Analysis of Teaching and Learning	1a	Assessments for Differentiation
	1e	Positive Feedback
	1f	Good Student Test Scores
	5	Reflect
	21	Flexible/Adaptable
	22	Assess Lesson Objectives
Personality	19	Organized
	20	Enthusiasm
	23	Previous Experience
Beliefs	1h	Growing Professionally
	16	Efficacy
	18	Grow Professionally
Colleagues	1c	Collaboration With Colleagues
	4	Collaborate
Current Job	24	Resources
	25	Job Satisfaction
UTeach Preparation	26	UTeach
	27	Pre-UTeach
	28	Post-UTeach
	31	Achieving Success

Appendix B

Permutations for the Alignment of the Three-Part Framework

	UTeachers' beliefs about excellence in teaching	*Related to UTeach framework (UTOP) of excellence in teaching*	*Observed practices and enactment (along UTOP instrument)*
1	X	X	X
2	X	X	
3	X		X
4	X		
5		X	X
6		X	
7			X
8			

Row 1, for example, would be an attribute that the beginning UTeachers' believed to be important for excellence in teaching (Study 1), that was related to the UTeach framework (UTOP), and was observed in beginning UTeachers' teaching practices (Study 2).

While these are all possible permutations, the data collected from the two studies would not be able to address all eight of the different permutations. The eighth row, for example, would have no data from either study associated with it. We focus primarily on the first two rows in this study as a reflection on teacher education.

Note

1. The five Es in the 5-E lesson model stand for Engage, Explore, Explain, Extend, and Evaluate throughout.

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