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Abstract

Recruiting people with rich backgrounds in science, technology, engineering, and mathematics (STEM) into the teaching profession has historically been difficult and remains so today. In this bounded instrumental case study, undergraduate STEM majors were trained and placed as science and math tutors in grades 9-12, with an overarching goal of encouraging them to consider teaching as a possible career path. Several themes emerged from the tutors' experiences as significant in their willingness to consider a career in teaching, including altruism from helping others, satisfaction from tutees' improved academic performance, and a more nuanced understanding of the complex nature of teaching.

Keywords: tutoring, STEM teaching, teacher motivation, teacher recruiting, career satisfaction, intrinsic motivation, teaching as complex

Introducing STEM Majors to the Teaching Profession Through Authentic Experiences as Tutors

Whether you like it or not, history is on our side. We will bury you.

Nicolai Khrushchev, Premiere, USSR

Finding enough good science and math teachers is an old problem. It is also, according to many, a critical problem. A watershed moment in US-USSR relations during the Cold War illustrates both the problem's persistence and its criticality. In November of 1956, Soviet Premiere Khrushchev delivered his now infamous remark (above) in a speech to a delegation of ambassadors from the West, many of whom regarded his remark as an existential threat (*Foreign News: We Will Bury You!*, 1956). Less than a year after Khrushchev's speech, the Soviet Union demonstrated its ability to project nuclear force across continents by launching the first Inter-Continental Ballistic Missile (ICBM). Then, close on the heels of the ICBM launch, the USSR launched Sputnik, the world's first artificial satellite, into a low-Earth orbit. When the USA awoke on the crisp October morning following the Sputnik launch to discover that the USSR had beaten the USA into space, many viewed the engineering feat as evidence of looming Soviet technological, and therefore military, world dominance, and many in the states were quick to blame poor public education in science, mathematics, and engineering in America's K-12 schools for America's failure to measure up (Dickson, 2001). Responding to widespread fear that a continued failure of public schools to produce top-notch scientists and engineers would undermine the ability of the USA to meet threats from the USSR, the USA directed unprecedented resources toward bolstering national science, technology, engineering, and mathematics (STEM) education (see, for example, Boerner, 2009; Bruner, 2003; Dickson, 2001, Rutherford & Ahlgren, 1990; Smith & O'Day, 1990; Yager, 1996). In 1958, for example, the US

Congress passed the National Defense Education Act (NDEA), which added billions to the federal public education budget and resulted in sweeping changes in the way children were introduced to STEM subjects. Underlining the commitment of the times, in 1963, President Kennedy delivered a speech at the 90th anniversary convocation of Vanderbilt University (Kennedy, 1963), noting that "modern cynics and skeptics see no harm in paying those to whom they entrust the minds of their children a smaller wage than is paid to those to whom they entrust the care of their plumbing" (para. 15). Kennedy sandwiched the comment about low teacher salaries between remarks about putting a man on the moon within the decade and about Americans' patriotic responsibilities in times of tension, making clear the reasoning behind the sweeping national education reform policies of the late 1950s and 1960s that sought to bolster education, and in particular education in STEM areas: the nation was worried about being left behind; many saw STEM education reform as a path to technological and military supremacy; and the government was ready to fund the reform effort.

Of course Khrushchev's USSR did *not* bury the West, and military threats due to the technological prowess of competing nations do not loom as large as they did when Kennedy was president. However, many believe we now face other more pernicious existential threats, not as a nation but as a species, due to climate change and unwise global stewardship (see, for example Intergovernmental Panel on Climate Change, 2007; Union of Concerned Scientists, 2010). Therefore, and perhaps not surprisingly, according to many experts, a crisis of public STEM education *still* exists and is as urgent as ever, despite the massive efforts of the past five decades.

James Rutherford (1997), for example, characterizing some of the failures of these five decades of effort, suggests that the crisis lingers in part because of a misguided emphasis of many of the education reform attempts, noting that reform of the Cold War era was guided by the

assumption that content and methodology were most important, so "post-Sputnik concerns were curricular, focusing on what was being taught and how, rather than who was being taught" (para. 2). However, as any good teacher can attest, the process of educating a child is not as simple as curriculum or methods-centered reform efforts seem to assume.

The latest sweeping systemic STEM reform effort, spurred in large measure by the rise of Asian economies as US rivals, reflects a growing awareness in the general public that focusing exclusively on curriculum and methodology is unlikely to result in the kinds of improvement in student understanding of STEM subjects the public demands (Bowers, 1997). A more holistic approach to education reform that takes additional factors into account may be more successful. For example, in the context of teacher preparation reform, Grossman (1990) defined subject-matter knowledge as one of the four "cornerstones of the emerging work on professional knowledge for teaching" (p. 5). Similarly, Gess-Newsom (2001) posits "deep and highly structured content knowledge that can be accessed flexibly and efficiently for the purpose of instruction…will be essential in order to teach for understanding and to provide authentic opportunities for students" (p. 53). Following this logic, many people think recruiting people who have strong STEM background into the teaching profession may be a critical component of such a holistic approach (see, for example, Center for Educator Compensation Reform, n.d.; Darling-Hammond & Sykes, 2003).

Are teachers prepared to teach STEM?

It has been quite clear to researchers for years that teacher quality is among the strongest correlates of student outcomes (Darling-Hammond, 1999; Monk, 1994). Thus, many of the more recent reform efforts put a strong emphasis on teacher quality. The No Child Left Behind Act (NCLB), for example, requires teachers to become "highly qualified" by demonstrating subject

matter competence in core subject areas, with one path to becoming NCLB compliant requiring completion of significant university coursework in the content areas in which they will teach (NCLB, 2008).

The unfortunate truth, however, is that as well intentioned as they may be, NCLB and other systemic policy efforts have failed to alleviate the chronic shortage of STEM-knowledgeable teachers in K-12 classrooms (Darling-Hammond & Sykes, 2003). Put simply, the US teaching force is not as qualified to teach STEM as it should be (Ingersoll, 1999). For example, fewer than 20% of middle school science teachers were undergraduate science majors, and in grades 1-4, fewer than 10% hold even a minor in science or science education (Greenwood & North, 1999). When coupled with evidence of a high correlation between student performance and the number of science and math courses their teachers had taken in college (Monk, 2004), these facts are alarming. Indeed, the 2000 National Survey of the State of Science and Mathematics Education (Weiss et al, 2001) reported that only about a quarter of elementary teachers surveyed felt well qualified to teach science and math.

Why the shortage of STEM qualified teachers?

Many researchers point to teacher attrition as a primary reason for the shortage of STEM qualified teachers (Gursky, 2001; Ingersoll & Smith, 2003). However, recruiting difficulties, particularly in STEM areas, also play a role (Weld, 1998). A joke teachers tell gets at the heart of one possible explanation for the shortage: *You know the difference between a large pizza and a teacher? A large pizza can feed a family of four!* Like most good jokes, this one contains more than a little truth. Marx and Harris (2006) report that in Arizona, for example, among fields that require 4-year degrees, average teacher salaries rank in the15th percentile range and that top teacher salaries are lower than many entry level engineering positions. As Marx and Harris

(2006) write, “although it is clear that compensation is not the only or even the most important reason… it certainly is *one* reason” (p 473). Similarly, a review of recent literature by Guarino et al shows that cross-sectional variation in salary is clearly associated with teacher recruitment (Guarino et al, 2006). This is consistent with the economic labor market theory of supply and demand as applied to teacher labor markets, which posits that the number of people willing to work as teachers is directly and positively related to the desirability of the teaching profession as compared to alternative available professions (Haggstrom et al, 1988). In short, recruiting teacher candidates with rich backgrounds in STEM subjects into the teaching profession has historically been difficult and remains so today in large part because of the all-too-accurate perception that teachers are poorly rewarded relative to scientists, technology experts, engineers and mathematicians. In an environment in which the average starting salary of an undergraduate-trained mechanical engineer in the US is $55K but the starting salary of a teacher is only $31K (Bureau of Labor Statistics, 2008), many STEM trained people rightly ask, “Why be a teacher?”

Of course quite a few people with rich STEM content knowledge *do* become teachers, and they offer many viable and compelling answers to that question. Perhaps not surprising to anyone who has taught, their answers often rank salary considerations relatively low in importance. In one study, practicing teachers in a large urban setting cite enjoyment at seeing the students learn new things and making a difference in students' lives as the two leading reasons why they teach, and identify intrinsic rather than extrinsic rewards as most important to their general job satisfaction (Bradley and Loadman, 2005). As this and a raft of other research shows, people generally become teachers not because it pays well, but because it is personally rewarding.

Guarino et al (2006) report that one intrinsic factor in particular may be a primary

motivator for becoming a teacher: an altruistic desire to serve society. This suggests that teacher recruitment programs designed to help people find resonance with the intrinsic rewards of teaching, such as altruism, and that allow for meaningful evaluation of the teaching profession from first-hand experience, may be effective. This study presents one such program and describes some of the experiences perceived by participants as significant in their willingness to consider a career in teaching.

Methods

This study represents a bounded instrumental case study (Creswell, 2007; Sandman-Hurley, 2008; Stake, 1995). Selected participant experiences within a single tutoring project are highlighted specifically to illustrate aspects of the tutors' perceptions of the project that seem important to their consideration of STEM teaching as a viable career possibility. As with all such case studies, the present study is not intended to define or characterize universal themes common to all similar situations, but rather serves to illuminate specific interactions and perceptions situated in the context in which they occurred. No causal inferences regarding relationships between any given variables implicit in this study can be made from the present case, and generalization from the present case to other cases should be made cautiously.

The Tutoring Project in Brief

The tutoring project, which spanned the Spring 2009 semester, was offered in connection with the College of Education at a large urban university that is a part of the California State University system.[1] The project had two primary goals. The immediate goal was to provide high school students struggling with academic progress in math and the sciences with ongoing access

[1] Unlike most other states, California does not certify its teachers via undergraduate programs in which students major in education, but rather relies on a system of post-baccalaureate teacher credential programs as the major source of K-12 credentialed teachers. As a result, there is no education major available to undergraduate students at the university where this study was conducted.

to tutors with strong content knowledge in chemistry and mathematics. The overarching goal was to expose undergraduate STEM majors to the teaching profession in a forum that allowed them to experience the joys, satisfaction, complexities and fulfillment of teaching first-hand, and simultaneously to investigate the viability and effectiveness of this approach in encouraging undergraduate STEM majors to consider careers in teaching.

Selection of Participants/Tutors

About two months before the Spring semester began, a series of recruitment flyers were placed in science, mathematics, and engineering buildings on campus advertising the opportunity to become paid tutors of middle and high school students in STEM areas. Over 45 students showed interest and attended an orientation meeting that introduced the project and described the tutors' duties and responsibilities. Funds were not available to support such a large number of tutors, however, so a survey instrument was developed to aid the selection of tutors from this pool. (The survey instrument can be accessed at http://www.surveymonkey.com/s.aspx?sm=eUqkIJnuYy9DnlVw5_2f84bA_3d_3d). Thirteen individuals were selected, eight young women and five young men whose career interests, tutoring experience, STEM content knowledge, dispositions, and availability seemed particularly suited to the program goals. Those selected were between the ages of 19 and 24, and all had completed *at least* two years of study toward a STEM area major at the undergraduate level (six sophomores, five juniors, and two seniors) and all maintained at least a 3.0 GPA (self-reported). In addition, each of the selected tutors indicated that they were at least *somewhat* interested in the possibility of pursuing a career in K-12 education. Table 1 shows the gender and undergraduate majors of the tutors.

Table 1

Gender and Undergraduate Majors of Tutors

Major	Males	Females
Biology	0	1
Chemistry	0	1
Math	1	2
Engineering	2	3
Computer Science	2	0
Social Work (Pre-Med)	0	1

The tutors agreed to commit between 10 and 20 hours per week at $15 per hour at an area high school in one-on-one or small group settings with students in grades 9 through 12.

Tutor Training

Four 2.5-hour seminars were held over the course of the semester – one each month starting in early February and continuing through May. Seminars focused on aspects of teaching methodology and educational psychology of particular utility to novice STEM tutors. Drawing from the work of Rabow et al (2007), specific topics for the seminars focused on four major themes, described below.

The initial seminar focused on helping tutors understand and manage initial attitudes, anxieties and expectations. Specifically, the seminar centered on helping tutors develop realistic and healthy expectations toward the tutees and the tutoring experience, managing anxieties regarding being a tutor, understanding the tutor's role, understanding the tutees' needs, and building appropriate and useful relationships with tutees and others at the school site. At the beginning of this initial meeting, after a few clerical concerns regarding record-keeping procedures, payment procedures, and the like had been addressed, tutors were asked to hold up fingers to indicate on a scale of one to ten the level of anxiety they felt regarding four concerns,

with one finger representing low anxiety and ten fingers representing high anxiety. Consistent with Rabow's (2007) experiences with beginning tutors, all 13 of the participants in this project indicated moderately high to high anxiety (five to ten fingers aloft) when asked in turn if they were worried about students not liking them or them not liking the students, about working with students from different backgrounds, about their abilities to teach, and about their abilities to help their tutees succeed. After a brief whole-group discussion about these remarkable commonalities, each tutor generated an individualized list of concerns s/he was most worried about. The tutees then read four short illustrative cases taken from Rabow (2007) and discussed each in small groups with instructions to look for intersections between their lists and the cases. The cases focused on (1) unconditional acceptance of tutees (pp. 9-11), (2) giving up expectations and preconceptions of tutees (pp. 14-18), (3) displaying genuine interest in the lives of tutees (pp. 19-21), and (4) communicating empathy (pp. 21-22). This was followed by a whole-group discussion in which participants shared insights they developed in small group discussions regarding their concerns. The seminar ended with a share-out of any concerns from the tutors' lists that were not addressed in the small group discussions. Notably, a second informal survey at the end of the first seminar along the same four dimensions probed by the initial informal survey revealed that almost all (11 of 13) tutees felt much less anxious about the prospect of tutoring (1-5 fingers aloft) than they did initially.

The second seminar explored how to build trust, how to set appropriate boundaries with tutees, how to engage tutees in learning tasks, and how to structure learning tasks to be appropriately challenging to tutees. This seminar was held after all of the tutors had visited the school site and had met some of the tutees. In this seminar, we began by recounting in small groups some of our initial experiences at the school site and with the tutees. Following this

discussion, each tutor was asked to recount two or three specific experiences related to a connection that s/he made with a tutee, such as the discovery of a common interest or a gesture of trust or acceptance on the part of the tutee. These specific shared experiences allowed for focused small group discussions of several themes related to becoming an effective tutor. These themes included how to find common interests, how and why to avoid the dangers of using gifts and bribes to motivate (e.g. "I'll give you this really nice pen if you finish the worksheet."), helping tutees overcome past negative experiences with tutors, showing appropriate respect for tutees, establishing healthy reciprocity by sharing appropriate personal stories and experiences with tutees, and helping tutees set and meet appropriate academic goals. The seminar ended with a whole-group discussion that summarized the small-group discussions; during the discussion, each tutor was asked to generate notes about practical strategies they could use to address some of the specific needs of their individual tutees.

The third seminar sought to explore how to foster tutee involvement and interest in learning, and in particular, how to let tutees take the lead in learning tasks via inquiry, following Rabow's (2007) suggestions and insights regarding successful teaching techniques and strategies for use by tutors with tutees from varied backgrounds. Thus, we began with a brief introduction to inquiry learning (Bass et al, 2008) in which tutors were presented with a discrepant event (a cup of water is covered with an index card and inverted: the water does not spill out). Tutors were given cups and index cards and were asked to explore the phenomenon in pairs in order to generate a series of conjectures and hypotheses, and to work toward a possible explanation of the phenomenon. After a brief exploration phase, we held a whole-group discussion in which we generated an academically acceptable explanation of the phenomenon. We then discussed the power of self-directed learning to motivate, the ability of inquiry strategies to hold student

interest in learning, and the satisfaction that can derive from solving an initially mysterious puzzle, or, in the words of one of the tutors, "the rush of feeling the pieces fall into place!" With this seminar experience in common, we focused the discussion back on the job of tutoring. Tutors discussed in small groups some of the difficulties they had experienced at the school site regarding getting tutees engaged in learning or keeping tutees challenged and interested. Using insights derived from their experiences with the inquiry activity that began the seminar, each group generated a collection of ideas and possible strategies that might address the specific difficulties their tutees were having. The seminar ended with a whole-group discussion regarding how an inquiry approach to learning can create opportunities for cross-cultural connections and can reduce barriers arising from cultural or language differences by providing those involved with a common experience or phenomenon to explore together (Bass et al, 2008).

The final seminar introduced approaches, strategies, and methods to bring the tutoring experience to a close at year-end. As Rabow (2007) notes, "Forming a strong, successful tutoring relationship and overcoming the various obstacles in its way are among the most difficult tasks a tutor faces. Equally critical, and perhaps equally difficult, is ending that strong partnership" (p. 161). Thus, this final seminar helped tutors explore the importance of ending their tutoring activities in constructive ways. The seminar opened with a share-out of tutor-tutee experiences and interactions that illustrated the depth of the partnerships that had developed over the course of the semester. Tutors then read and discussed in small groups three illustrative cases taken from Rabow (2007). The first two cases illustrated some of the common pitfalls that tutors can make, such as not saying goodbye at all (pp. 167-168) or making empty promises (pp. 169-170). The third case illustrated what Rabow (2007) calls "The Clean-Break Principle" and highlighted some characteristics of an effective goodbye (pp. 175-177). After the small group discussions,

tutors generated ideas about how to end their tutoring relationships, and each tutor briefly described one or more of the relationships they had formed with tutees over the semester and then shared their ideas with the other seminar participants about how to bring the experience to a close. The final seminar ended with a brief share-out by the tutors of the tutoring experience as a whole.

The Tutoring Site

The tutoring site, one of the oldest public high schools in California, is a relatively small yet comprehensive high school with just under 1000 students in grades 9 through 12. About 75% of the students identify themselves as Hispanic or Latino, about 10% as white (not Hispanic), and the remainder either as Asian, Filipino, African American, American Indian, Alaskan Native, or Pacific Islander. About 65% of the students are economically disadvantaged, and about 35% are considered English learners. The school is staffed with 4 administrators, 55 credentialed teachers, an academic advisor, and support staff. Six percent of the core classes are taught by teachers who do not meet NCLB compliance requirements. The school prides itself on offering a rigorous and demanding curriculum in a supportive atmosphere, and in 1990 the school site became a district magnet for the International Baccalaureate (IB) Diploma Program, recognized and accepted by universities worldwide as a rigorous and comprehensive pre-university education. Most of the tutees had been identified by their teachers as needing extra help in STEM subjects in general and math and chemistry in particular, although a few sought out the tutoring sessions on their own. Also, several of the tutees were involved in the IB Diploma program. The majority of the tutoring sessions were offered through the Homework Center, an after school program available Mondays through Thursdays, although a significant

number of sessions were held during school hours, either as pull-out sessions from established classes, or as assistance instruction during classes.

No formal data regarding the tutees were generated or maintained; consequently, it is not possible to provide more than a cursory description of who the tutees were or what their individual needs might have been. However, based on informal observations and field notes, it can be reported with confidence that the tutees, who numbered well over 30, represented individuals from many if not most of the socio-economic, cultural and linguistic groups making up the school's student body. Tutees included academically high-achieving students as well as struggling students, native speakers of English as well as native speakers of Spanish, Tagalog, Vietnamese, and other languages, students who seemed economically well-off as well as students who seemed economically disadvantaged, and roughly equivalent numbers of students of both genders.

Data Collection

Data came from five sources: (1) an initial online survey, (2) weekly tutor's logs, (3) tutoring journals, (4) a closing open-ended questionnaire, and (5) seminar leader's field notes. First, the online survey instrument used during the initial selection process provided demographic data such as undergraduate class standing, subject major and languages spoken. The survey also provided descriptions of prior tutoring or teaching experiences and potential interest in pursuing teaching as a career. Second, the tutors kept weekly logs documenting each tutoring session (e.g. time, date, tutee name(s), subject area, and a brief description of activity). Third, the tutors kept written records of their tutoring experiences in journals in which they reflected on insights they had about their tutoring, the tutees, the tutoring process, and other significant experiences at the school site. The journals differed from the weekly logs in that they

were meant to capture the tutors' subjective experiences in more depth than the more quotidian records kept in their weekly tutoring logs. Fourth, at the end of the year each tutor provided a three to six page response to a questionnaire containing four open-ended prompts designed to gauge the extent to which the tutoring experience met their expectations and whether it resulted in meaningful or transformative experiences likely to influence their career plans. The prompts were as follows: (1) What were your ideas/expectations regarding tutoring in general? How have they changed over the course of the semester? (2) What new insights do you have about the teaching profession? Have your views about teaching and teachers changed as a result of your experience as a tutor? If so, how? (3) What has been the most challenging aspect of the tutoring program? and (4) What has been the most rewarding aspect of the tutoring program? The fifth data source consisted of field notes generated immediately after each seminar that sought to record information communicated in informal conversations during the tutoring seminars. Although these field notes do not offer verbatim accounts of conversations, they intended to capture the essence of what was said.

Data Analysis

Data analysis followed Creswell's (1998) guidelines for categorical aggregation, interpretation and generalization. Weekly logs, tutoring journals, culminating written responses and field notes of informal conversations occurring during seminars were systematically examined for issue-relevant meanings. Each artifact (e.g. a student journal, or a weekly tutoring log) was read a minimum of four times, with a minimum of two days between subsequent readings. Line by line coding was conducted using an unmarked copy of the text for each reading, with provisional codes applied to phrases, sentences, and segments of text that appeared to be related to the tutors' consideration of STEM teaching as a viable career option. During this

initial stage of data analysis, the net was cast widely, and a very broad interpretation of the construct "related to STEM teaching as a viable career option" was operationalized, resulting in the generation of a relatively large number of codes. These codes were developed during the reading of the artifacts themselves while simultaneously keeping information from the literature in mind, using a methodological process that Miles and Huberman (1994) describe as "partway between the a priori and inductive approach" (p. 61). For example, because Marx and Harris (2006) identified teacher pay as important, the phrase from a tutor's journal "salary of an engineer" was identified and coded, as was "low teacher pay." Both were given the code "compensation." In addition, the journal entry phrase "the feeling you get when you help a kid" and the sentence "I didn't think I'd enjoy it as much as I am." were also coded (positive feeling). After each artifact was coded four times, the four code lists that resulted were compared and an attempt was made to form a single internally consistent code list for each artifact by revisiting the artifact once more specifically to re-examine areas of differences in the four code lists. The process was repeated with all artifacts, resulting in a large set of both etic and emic codes representing the data from four of the five data sources used in this study. (The initial survey was not coded).

This extensive code list was then examined to identify larger categories and to locate emerging themes within these categories (Adcock and Collier 2001). These categories and themes were identified using a process of direct interpretation: the presence of a given code was considered as representing a single instance of a construct without attempting to look for multiple instances or to divine the context in which the construct was situated (Creswell, 1998). Thus, each individual code was assigned to one or more category directly, without further examination of the data, and the resulting categories were then examined to identify underlying

themes. For instance, from the above examples, the phrases "salary of an engineer" and "low teacher pay" were both coded as "compensation" while the phrase "the feeling you get when you help a kid" and the sentence "I didn't think I'd enjoy it as much as I am" were coded as "positive feeling." Both of these codes, "compensation" and "positive feelings," were identified as falling under the broader category of "motivation," with the first two codes in the category representing the theme "external motivation" and the second two codes in the category representing the theme "internal motivation." In this way, codes were aggregated into categories, and categories were organized into themes.

Once themes related to teaching as a career possibility were identified, the data was examined once again with these themes in mind in order to make what Creswell (1998) refers to as "naturalistic generalizations." Thus, themes from one data source (e.g. a particular student's tutoring journal) were cross-referenced with themes from other available data sources (e.g. that student's responses to the culminating survey or notes of conversations between that student and the researcher) in an attempt to gauge the significance of the theme and the characteristic of its relationship to other themes. Cross-referenced themes that emerged as particularly important in relation to the tutors' consideration of STEM teaching as a viable career possibility, or what Creswell (1998) might call a set of naturalistic generalizations, are presented here.

Outcomes and Discussion

Several factors seemed to play an important role in tutors' favorably considering teaching as a career. Three major themes are reported here: tutors' positive perception of the value of their work; tutors' positive perception of their aptitude for teaching; and tutors' perception of teaching as a complex act. The following section is organized into three sub-sections, each corresponding to one of these three themes.

Tutors' Positive Perception of the Value of their Work

The first theme relates to the tutors' perception of the value of their work in terms of tutee improvement. Most of the tutors dedicated well over the required minimum of 10 hours per week to tutoring, with nearly a quarter of them logging up to (and over) 20 hours per week, and while no formalized attempt to gauge the impact of the tutors' efforts on tutee learning was carried out, entries from the tutors' journals provides consistent anecdotal evidence that tutees benefited from the relationships. Without exception and on numerous occasions, tutors reported that their efforts with tutees resulted in performance gains on class assignments and tests. This perception on the part of the tutors gives rise to the first important and common theme. At the beginning of the project, many of the tutors doubted their ability to have much of a positive impact on tutee performance; when their efforts bore the fruit of tutee academic improvement, tutors experienced it as a positive intrinsic reward for their work. Jason provides a typical journal entry.

> Jason[2]: I feel that the most rewarding aspect of being a tutor was when I get to see the improvement in the kids. … seeing the kids that were struggling and failing when we first got there, to seeing them excelling and achieving in the classes now. And I'm proud that I could be a part of that.

Hai conveyed a similar thought in her end-of-year survey response.

> Hai: When I think about what's been the most rewarding part of the job, I think about the students I helped. I remember wondering if I would be able to get them to do anything or to help them at all because I thought that if they were going to a tutor it was because they were bad at whatever, math or science. But I found out that a lot of them were there

[2] Pseudonyms are used throughout this study.

> because they wanted to do better, not because they had to be there. I think I did help them and that was really rewarding.

Almost every tutor (12 of 13) expressed a similar feeling of pride or satisfaction at having helped a tutee improve his or her academic performance. To be sure, evidence of student improvement is dubious when self-reported by individuals with extremely limited or no experience teaching or evaluating student academic progress. However, given the preponderance of such evidence from most of the tutors' journals, it seems reasonable that the tutors had at least some positive effect on student learning. And even if academic gains were minimal, non-existent, or resulted from factors other than the tutoring sessions, tutors perceived that their actions brought about student improvement, and as Jason's comment illustrates, that perception seemed to bring great satisfaction. This finding is well aligned with findings of several large quantitative studies, such as Bradley and Loadman (2005), who report that the most important determining factor related to the job satisfaction of practicing teachers is the intrinsic reward that comes from helping children. This is also consistent with studies, such as Moran et al (2001) and Guarino et al (2006), that report altruism as a positive motivating factor.

Tutors' Positive Perception of their Aptitude for Teaching

A second theme that seemed to play an important role in tutors' favorably considering teaching as a career arose from the opportunity to experience teaching first-hand in an authentic context. It seems that the authenticity of working at a school site became an avenue for appraising initially-held ideas and assumptions against a set of actual experiences and that this authenticity allowed many of the tutors to think more deeply about the idea of becoming a teacher and their individual aptitude for it. Specifically, differences in many of the tutors' initial expectations and their actual experiences seemed important in their assessment of their own

suitability for teaching: many of the tutors seemed to hold more positive views about teaching and their suitability for it in the later stages of the tutoring project than they did initially. Not surprisingly, this change of perception often translated into a more positive view of teaching as a viable career choice. A mid-project journal entry from Antonio illustrates this theme well.

> Antonio (mid-March): At first I was nervous about tutoring these students. I have a little brother back at home who goes to elementary, and he drives me nuts sometimes. So I was imagining a roomful of students just like him. I was expecting the kids to be hard to work with since they are only kids. I was not sure if could connect with them, or that they would just see me as an outsider and not pay any attention. Luckily after working these past few months, my [experiences] are more positive. The kids are very welcoming to me, and sometimes prefer to work with me on some assignments. They mostly pay attention and they are definitely not the troublemakers that I was dreading at the beginning.

Here, Antonio expresses initial reticence about the prospect of being a tutor and doubts his abilities to succeed even in this limited teaching role, yet after only a couple of months on the job his nervousness has evaporated and his view of students is more solidly grounded in meaningful and contextualized understanding of the nature of working with students. In fact, as he reported in two separate journal entries, Antonio's view about his abilities to reach students and help them learn metamorphosed rather remarkably in a very short time – a fact that seems integrally related to his increased willingness to give a career in teaching serious consideration. As the two journal entries below illustrate, both his increased understanding of the nature of

teaching and his increased confidence in being able to succeed at it inform his thinking regarding teaching as a possible career.

> Antonio (late March): I feel great when students participate when I am going [over] a problem with them instead of just sitting around waiting for the answers. They … get involved and try and solve the problem. It makes me feel that I am actually making a difference!
>
> Antonio (early May): Along with engineering, teaching was always an interest for me. I always liked helping others with their work, especially when they finally got it (the "aha moment" we talked about in the seminars). Tutoring at the school has definitely made me more interested in teaching. I really enjoyed working with the students and a teaching career would also make [me] feel that [I] could help students succeed and make a difference.

Similarly, in her first journal entry, Mika remarks about the rapidity with which the differences between her expectations of the tutoring experience and her actual experience collided.

> Mika (February): I really had a lot of anxiety going in. I figured that it was just gonna be a waste of time and I just thought I wasn't gonna make any difference. I figured it was just a way to make some money but that it wasn't gonna do much good. But after the first few times, especially when I got to work with the same student with her math more than once, I started to think I'm really helping this kid! That felt good.

Later that month, Mika made a connection between her positive experiences with students, her changing attitudes about being a tutor, and a growing awareness that she may even have an aptitude for it.

> Mika: (journal entry, late February): I'm enjoying this [tutoring] more than I thought I would. The money's not great. I mean it's not bad, I can pay my phone [bill] with it. But I really like going to the school and not just for the money. There are a few of the kids I can tell that I'm actually helping. They're learning. And I didn't really know if I could do that at first. I think I was worried that I would be bad at it so I didn't get into it at first.

This awareness that she might not be as bad at tutoring as she had initially thought, in turn, seemed to be related to her musings about a future teaching career in a conversation we had during the second seminar. Mika responded to a direct question regarding what she thought about the possibility of becoming a teacher, saying (paraphrased in field notes), "It seems like a lot of people talk about wanting to be a teacher when they grow up. I thought about it when I was younger. But I hadn't thought much about it since I started college, until I became a tutor. I like tutoring, so now I'm thinking about it. It's a possibility."

Jason also reports significant differences between his expectations of the tutoring experience and his actual experiences - differences that plainly improved his view of the teaching profession. Interestingly, however, Jason's observations center not on his expectations regarding his ability to help students, but on his interactions with the teachers and administrators.

> Jason (early May): I expected the relationship with the teachers at [school site] to be much different. I didn't think that they would be so happy about us coming in and taking some of their kids and us teaching them. But what happened was the complete opposite.

> The teachers were glad that we were there. Not to mention the two vice-principles [sic] as well. They were constantly praising our work, telling us what a good job that we have done. And that made me feel good, and made me want to work harder and make the kids learn more.

Six other tutors, along with Antonio, Mika, and Jason (for a total of nine of the 13), expressed similar views, indicating that their actual experiences of tutoring were very different, and more positive, than their initial expectations. Of the nine who expressed that their actual experiences were more positive than initial expectations and noted a more positive assessment of their suitability for teaching, five cited this change as an important contributing factor in their willingness to consider teaching as a career. This theme is consistent with expectancy-value motivation theories, such as Wigfield and Eccles (2000), which posit that perceptions of one's ability are important in motivation. In the present case, the change in perceptions of five of the tutors' suitability for a teaching career seemed to act as a motivator to consider the profession as a career option.

Tutors' Perception of Teaching as a Complex Act

While the two themes reported above are generally consistent with much of the literature on teacher motivation that reports the strongest motivations for choosing teaching include intrinsic factors such as an altruistic desire to help children and a positive perception of teaching abilities (e.g. Richardson and Watt, 2006), Jason's observations regarding his acceptance at the school site also hints at a third theme that emerged as important: a view of teaching as a complex act. This theme of teaching as a complex act is not as well documented in the literature.

Jason's points at this theme in several journal entries. For example, his initial expectations were that the professional educators at the school site would resist his efforts or

perceive him as an outsider encroaching on protected turf. But when school staff reacted quite differently, not only did it have an effect on his own willingness to work hard, it also caused a shift in his understanding of what teachers do for a living.

> Jason: (early May) My views of teachers have definitely changed. I have experienced many teachers that I felt that I could just never learn from. Simply, I thought that they were "bad teachers." But I realize now that all teachers want their students to pass and do well. I have seen some of these kids be incredibly rude and disrespectful to teachers, and the teachers give them detention after school. And instead of the teachers blowing them off, and ignoring them the whole time, they put effort into helping them learn the material that they may have missed while they were disrupting the class.
>
> Jason: (early May) I realize that a high school teacher's job goes far beyond the classroom, the students, and their parents. They are very much involved in these kids lives.

Here, Jason's appreciation for the complexity of teaching seems to be increasing. Concurrently, his growing enthusiasm for the job seems to be keeping pace. It is possible that Jason's view of the complexity of teaching as a positive motivator – to the extent that this is a correct interpretation of his view – is related to an appraisal of teaching as an intellectually stimulating career. This factor is recognized as an important motivator by several researchers, such as Sinclair et al (2006), who developed a psychometric tool to measure teacher motivation, *Modified Orientation to Teach (*MOTS), and found the construct useful as an internal (intrinsic) adaptive scale of measurement related to teacher motivation.

Another tutor, Martin, evidences the theme as well. He came to understand that teaching is more than just a cut-and dried procedure in which a content expert dispenses content knowledge but is instead a complex endeavor that requires strong content understanding, flexibility, a thorough understanding of the student, and a nuanced sensitivity to context. In this context, it is perhaps significant that Martin is an upperclassman approaching the completion of an undergraduate degree in mechanical engineering. When asked why he had chosen to study engineering, he said that he viewed engineering as a problem-solving endeavor that would keep him challenged and thus intellectually engaged, which he indicated was very important to him. In addition, he often spoke about the satisfaction that came from working with others on complex and authentic engineering projects in his upper-level classes. In short, he expressed the idea that the complexity of being an engineer would hold his interest. Notably, in seminar conversations, he often expressed that as difficult and rigorous as his university level engineering curriculum has been, he has often found his role as a tutor to be equally challenging, quite rewarding, and ultimately perhaps even life-changing. The following quotes seem to indicate a growing awareness that teaching may offer similar intellectual challenges and opportunities to Martin as engineering, challenges and opportunities he clearly values.

> Martin: (March) I have learned that when tutoring I shouldn't expect a mechanical approach. Sometimes I will have to move towards the student in order to teach them.
> Martin: (April): The students actually appreciate me being there to help them! It's amazing how each time I enter they all say "hi" or "yay! he is here today!" And also when they [have] confidence enough to thank me or talk about random things. For example a girl, Maureen, would come in during recess and start asking me question about

> college or if I ever eaten some random dessert and how it's really good. Her innocence … is what I enjoy from spending my time with them.
>
> Martin: (early May) Overall this experience has made me want to become a teacher even more.

Taken separately, these journal entries may seem to indicate merely that Martin's interpersonal experiences involved a recognition that teaching is socially involving, requires significant skill at recognizing changing student needs, and that is accompanied by interactions with people that go far beyond what he expected. However, when contextualized with other data, these entries seem also to reveal that Martin highly valued these complexities. On many occasions in conversation, for example, Martin confessed that before his experience as a tutor, he held a view of teaching as a far more mechanical endeavor than his actual experience revealed it to be, and his changing view was accompanied by a growing appreciation for the profession.

Stewart seemed to hold similar views. In a response to the open-ended questionnaire prompt, "What new insights do you have about the teaching profession? Have your views about teaching and teachers changed as a result of your experience as a tutor?," Stewart expressed this theme quite plainly.

> Stewart: I learned this: Teaching isn't easy! I may know about math, but teaching it to someone else is something else altogether. I can see how it would take a long time to get good at it. We learned some [information] that was helpful in the seminars, and I would watch the teachers at [school site], and I can see that there's much much more I'd have to learn to be a good teacher.

Notably, Stewart connected his newly found appreciation for the complexity of teaching to an increased willingness to consider it as a worthy profession. When asked whether this view of teaching as complex made the career more or less appealing as compared to other careers he might choose, his response, paraphrased below, was clear.

> Stewart: I'm a math major because I like to solve problems. I like the way you can take a concept and use it in a variety of ways to find answers to a lot of different problems that are very difficult, and that you can't solve any other way. I can see that teaching might be like that too. It's complex, but it also seems like there are methods you could get good at.

Aside from Jason, Martin, and Stewart, two others (for a total of five of the 13) expressed similar conceptions of teaching as a complex act and connected that perception it to an increased willingness to consider teaching as a career.

In addition to these three themes, another simpler theme emerged in the present study: not at all surprisingly, simply having positive experiences as a tutor seemed to play a role in tutors' favorable consideration of teaching as a career possibility. Of course, merely having a positive tutoring experience is unlikely to be a sufficient cause for someone to consider becoming a teacher; however, in Kristin's case it may prove to be!

> Kristin: (late March) Sometimes the students I normally work with are not in class so I have to tell the teacher I need another student, and when all the kids raise their hands to work with me, it feels nice… I had forgotten how it was to be in school, so with this experience I have been exposed to being in a school environment once again. I feel like I might not want to teach really young students, but I still want to teach.

Similarly with Shuo and Michele, who were both already strongly considering teaching careers, their overall positive experiences as tutors bolstered their resolve to become teachers. Specifically, Shuo highlighted camaraderie with the staff and students as important factors.

> Shuo: The teachers made it enjoyable and the students were fun to work with. I want to become a math teacher one day, and to have this experience made me want to continue in that direction.

Michele seemed to be well on her way toward developing the outlook of a practitioner and was eager to sharpen her skills in anticipation of entering the profession.

> Michele: The workshops were helpful because they provided tips and tools for tutoring in the classroom. During this semester, I have gained more passion to teach in the future. It is rewarding to see students succeed and to know that I am part of their success. My views have changed … I have a greater willingness to pursue a career in education.

In Carolyn's case, the experience provided a forum for her to explore her own motivations in an authentic context.

> Carolyn: From this job, I was able to learn a lot about myself and what drives me. I had a chance to narrow down and think about what I enjoy and want to do. I thought I would work with kindergarten/preschool. But now I also would like to work with middle school and high school students.

Conclusions

Writing about the challenges of recruiting teachers into the profession, Thornton and Reid (2001) note that although some people wind up in the teaching career because they have

limited options elsewhere, they state that, "Ideally it would seem best to 'pull' recruits towards teaching, as a positive career choice, rather than to 'push' them. The best way of accomplishing this appears to be positive work experience in schools." (p. 112). This may be especially important with people who have significant training and expertise in STEM areas. This study suggests that programs designed to offer potential teacher candidates with rich STEM understanding authentic and meaningful experiences as instructors in classroom settings may be an effective way to pull them toward a career in teaching. As a result of participating in this project, eight of the 13 tutors expressed an increased willingness to seriously consider teaching as a career option, and all 13 tutors reported that the experience made the possibility more attractive. This is captured well by the observations of Michele and Liza, who after only one semester working with kids in schools were able to capture quite succinctly an idea that rings true for many of us who have been teaching for years.

> Liza: It feels really good when students get the "ah Ha!" and they thank me for it!
>
> Michele: The most rewarding aspect of tutoring was to see the students arrive at the "Ah, Ha!" moment…to see that grand smile on a kid's [face] and the kid saying, "Thank you, Michele."

In this light, and consistent with what Thornton and Reid (2001) suggest, the implications of the project discussed here are simple: it seems likely that if more STEM majors are given opportunities to experience what Liza and Michele experienced, more STEM majors might wind up as K-12 teachers. Aside from its potential utility as a teacher recruitment method, it is hoped that the methodological approach used in this bounded instrumental case study will add to the depth of the quantitative literature about what motivates people to choose teaching as a career.

The findings reported here regarding the first two of the three major themes that emerged from this project are generally consistent with much of that literature (e.g. Bradley and Loadman, 2005; Richardson and Watt, 2006). The third theme that emerged from this study is far less well established in the available literature. It is unclear from the present study why a view of teaching as a complex and nuanced endeavor rather than a cut-and-dried procedural exercise might have appealed to them, or indeed if such an interpretation is correct. However, it is reasonable to hypothesize that a view of teaching as a complex act is part and parcel of a view of teaching as intellectually stimulating, which Sinclair et al (2006) recognize as an important motivation to teach. Further exploration of this theme in particular may lead to a better understanding of the kinds of experiences that may lead STEM students into the teaching profession.

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