THE DEVELOPMENT OF A PROFESSIONAL STATISTICS TEACHING IDENTITY

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Motivated by the increased statistics expectations for students and their teachers because of the widespread adoption of the Common Core State Standards for Mathematics, this study explores exemplary, in-service statistics teachers' professional identities using a theoretical framework informed by Gee (2000) and communities of practice (Lave & Wenger, 1991; Wenger, 1998). Twelve exemplary, primarily Advanced Placement (AP) Statistics teachers participated in two semi-structured interviews. Findings indicate that these teachers developed teaching identities that cross the borders of mathematics and statistics, though these were not always recognized by administrators, other teachers, and parents. Two major contributing factors to the development of a statistics teaching identity—teachers' specialized knowledge and teacher isolation—are discussed. This work has implications for teacher preparation and professional development.

Keywords: Data Analysis and Statistics, High School Education, Teacher Beliefs, Teacher Education-Inservice/Professional Development

Background

Statistics is a mathematical science – like economics or physics – but is not a type of mathematics (Cobb & Moore, 1997; Moore, 1988; Rossman, Chance, & Medina, 2006; Usiskin, 2014). Still, statistics has been included within the mathematics curriculum at the K-12 level (National Council of Teacher of Mathematics [NCTM], 2000; National Governors Association Center for Best Practices, Council of Chief State School Officers [NGA & CCSSO], 2010) and will likely remain there for years to come (Scheaffer, 2006; Usiskin, 2014). Despite sustained calls for increasing the statistical preparation of teachers (e.g. Conference Board of Mathematical Sciences [CBMS], 2012), the current state of teacher preparation for statistics is regarded as inadequate (Franklin et al., 2015; Shaughnessy, 2007). While more mathematics teachers are being asked to teach statistics because of its inclusion in the Common Core State Standards for Mathematics (CCSSM) (NGA & CCSSO, 2010) in grades 6-12, teachers involved with the Advanced Placement (AP) Statistics program have already overcome challenges associated with an increase in statistics expectations. Therefore, AP Statistics teachers can serve as an analogue for understanding how mathematics teachers overcame challenges they encountered teaching at the border of mathematics and statistics.

Overview of the Study

A key expectation for mathematics teachers is that they develop a professional identity as such (NCTM, 1991). This professional mathematics teacher identity is fostered by teacher preparation programs, on-going professional development, and immersion in the school mathematics culture. However, the benefits of a professional mathematics teacher identity may not be directly applicable to teaching statistics, and there is little extant research on statistics teachers' identities (e.g. González & Zapata-Cardona, 2014; Peters, 2009). This study explores the professional identities of exemplary AP Statistics teachers at the high school level. The primary research question is: "What professional identities do exemplary statistics teachers develop?" Assuming that a statistics teaching identity is found, a secondary question is considered: "What are the major contributing factors to the development of a professional statistics teaching identity?"

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Theoretical Framework

There are several theoretical conceptions of identity in the literature. This study draws heavily on two conceptions of identity that form the basis for its theoretical framework: Gee's (1999, 2000) contextual or socially-situated identities and Lave and Wenger's (1991; Wenger, 1998) communities of practice. Other conceptions of identity have also contributed to this theoretical framework (e.g. Juzwik, 2006; Philipp, 2007; Sfard & Prusak, 2005).

Gee's (1999, 2000) conception of identity postulates a core identity that is stable across contexts and contextual identities that are recognized by others and more prone to change over shorter time frames. There are four perspectives for contextual identities described by Gee (2000) (natural, institutional, discursive, and affinity) which are "interrelate[d] in complex and important ways" (p. 101). By employing these four perspectives, identity can be examined in several ways which has implications both for data collection and data analysis. The contribution of contextual identities to the theoretical framework of this study is important because of the multiple roles which in-service teachers have in their careers.

Identity is at the heart of the communities of practice framework. In a community of practice, learning is synonymous with the development of the practices and identity associated with the community in question (Barab & Duffy, 2000; Lave & Wenger, 1991). Identity and practice are further connected through five modes of belonging: negotiated experiences, community membership, learning trajectories, nexus of multi-membership, and the local-global relationship (Roesken, 2011; Wenger, 1998). It is through these modes of belonging that perpetually in-development identities are examined. In this study, the most salient aspects of communities of practice are teachers' learning trajectories and their nexuses of multimembership. The use of both Gee's (1999, 2000) conception of identity and communities of practice (Lave & Wenger, 1991; Wenger, 1998) ensured that the data sources addressed identity in a broad manner.

Methods

Participants

Participants were recruited using *critical case* sampling, a sampling strategy that prioritizes specific, important participants. Patton (2002) characterizes critical cases as those for which the researcher can say "if it doesn't happen there, it won't happen anywhere" (p. 236). In the present study, successful, experienced statistics teachers constitute a critical case because their professional identities (as teachers of statistics) have enabled their success; if the teachers in this study do not develop professional identities that are aligned with teaching statistics then it would not be reasonable to believe that such identities would be developed by other mathematics teachers tasked with teaching statistics.

To identify these critical cases, referrals were solicited from experts in the statistics education community with far-reaching contacts and connections. These experts were asked to identify "statistics teachers that you consider to be exemplary … primarily at the middle and high school levels" in a broad sense: no restrictions were placed on experience, gender, courses taught, etc. From these sources, a list of 24 statistics teachers – all known primarily for their work teaching statistics at the high school level – was compiled. Each of these teachers was emailed and asked if they would like to participate in the study; all 12 who responded affirmatively were included.

Among the 12 participants, there were five women and seven men. The highest level of education was a bachelor's degree for two participants, a master's degree for seven participants, and a doctoral degree for three participants. While most of the participants earned degrees in mathematics or mathematics education (i.e. they had traditional mathematics teaching backgrounds), there were several notable exceptions. One participant's highest education was a master's degree in statistics, and another participant earned a doctorate in statistics. Additionally, one participant earned a

doctorate in a science. The participants were primarily mid-career and late-career teachers, having an average of 30 years of teaching experience; the minimum years of teaching experience was 7, the first quartile was 19.5, the median was 32.5, the third quartile was 42, and the maximum was 50. Pseudonyms are used throughout.

Data Source

Because of the rich, multi-faceted nature of identity, semi-structured (formal) interviews were employed for data collection. As recommended by Hatch (2002), the interview protocols were viewed as 'guiding questions' rather than enforcing a rigid structure. In general, two interviews lasting about 60-90 minutes each were conducted with each participant; exceptional circumstances resulted in only one interview being conducted with two of the participants for a total of 22 interviews. Questions on the interview protocol were written by the researcher in consultation with published interview protocols from studies using similar frameworks (e.g. Burton, Boschmans, & Hoelson, 2013; Carlone, Haun-Frank, & Kimmel, 2010; Krzywacki, 2009; Settlage, Southerland, Smith, & Ceglie, 2009). The use of semi-structured interviews allows participants to describe how they recognize themselves and how they perceive themselves to be recognized by other people (Carlone & Johnson, 2007). All interviews were transcribed.

Data Analysis

The data in this study are being analyzed using inductive analysis as conceptualized in Hatch (2002). This type of inductive analysis is characterized by repeatedly re-reading the data to identify and refine domains which are then used to find larger themes (Hatch, 2002). Throughout this process, data examined both to see if it supports the working domains and themes and to see if it runs counter to them (Hatch, 2002). This flexible data analysis framework was chosen because it is consistent with the constructivist epistemology used in this study and because it allows for the use of several data sources; beyond the semi-structured interviews used in this paper, quantitative surveys and a brief biographical sketch were used as data sources.

Results

To answer the first research question, the different contextual identities that participants had with administrators, other teachers, and parents are explored. To answer the second research question, evidence of two major contributing factors to the development of a statistics teaching identity distinct from a mathematics teaching identity are presented, statistics teachers' specialized knowledge and their isolation in schools. These two factors presented are a subset of major contributing factors that have been identified in this study.

The Professional Identities of Statistics Teachers

The participants in this study typically had several professional identities, notably both a professional mathematics teaching identity and a professional statistics teaching identity. In Gee's (2000) conception of identity, one's contextual identities are predicated on being recognized by others in a certain way, i.e. in a given context, others' perceptions of a person are a core part of that person's identity for that context. Several contextual identities are evident in participants' relationships with administrators, other teachers, and parents, and these different contexts are characterized by different trends in how participants are recognized. These results report on participants' perceptions of the perceptions that others have of the participants; ideally, the others (e.g. administrators) would be directly interviewed about their perceptions, but this would substantially increase the scope of this project.

Generally, participants reported that administrators viewed them as either a solely a statistics teacher (four participants) or as both a mathematics teacher and as a statistics teacher (seven

participants); one was viewed as exclusively a mathematics teacher. Administrators tended to view participants in the role of a mathematics teacher for two primary reasons: either they continued to teach mathematics courses or they had become the chair of their school's mathematics department. One participant who was viewed as both by the administration said, "they think of statistics as being math because it lives in the math department here, but some people—who know of my background in statistics—would refer to me as the as a statistics teacher" [Samuel:385-386]. The experience of the administration not differentiating between mathematics and statistics, except in specific circumstances, was common. Some participants reported being viewed exclusively as a statistics teacher by the administration: "I think primarily they view me they saw me as a stat teacher because that was my claim to fame … that was two periods of my six-period day but yeah they would say 'she's the stats teacher'" [Laura:473-475]. Great success teaching statistics tended to be a necessary but not sufficient condition for being recognized by the administration as exclusively a statistics teacher.

Other teachers tended to view the participants as either solely a statistics teacher (four participants) or as both a mathematics teacher and a statistics teacher (eight participants); none were viewed as exclusively a mathematics teacher by other teachers. Patricia described the reason she is viewed as a statistics teacher by other teachers saying:

> a stat teacher to the other teachers, only because statistics is fortunately popping up and all the other courses—not just math but also the science courses, in psychology, economics—so [if] somebody has a statistics question they usually end up in my room [Patricia:246-248]

Similarly, Louie was viewed as a statistics teacher exclusively saying, "even within the department … I think the perception is that I'm a stats guy who happens to be chairing a math department right now" [Louie:351-352]. Other participants were viewed as both by their colleagues, reflecting a recognition by their peers that teaching statistics differs from teaching mathematics.

This recognition as a statistics teacher did not extend to parents of their students, even when restricted just to students enrolled in statistics courses. Three participants were viewed exclusively as statistics teachers by parents, two as both mathematics and statistics teachers, and five were viewed exclusively as mathematics teachers; two participants felt unable to judge parents' perceptions of them. Participants were viewed exclusively as mathematics teachers by parents even when they only taught statistics courses; Paul describes the reason as, "[students] get a math credit for it on their transcript … [parents] don't necessarily think of it as a distinction between math and stats" [Paul:449-452]. This was a common experience for participants. Participants who were viewed as solely a statistics teacher or as both attributed this recognition to widely-known successes in their schools' statistics programs or highly-educated parents. Samuel, who is viewed as both by parents, describes them saying,

> we get a lot of students whose parents are faculty members … you know really highly educated … [they'll ask] 'do you teach t-tests?' … I got a parent asking 'oh, do you do randomization tests?' … they have in their mind what a statistics class [is] [Samuel:256-260].

However, most participants did not encounter parents with well-formed conceptions of a statistic class, and so were viewed more often as mathematics teachers by parents than by administrators or other teachers.

Depending on the context of an interaction (Gee, 2000) with administrators, other teachers, or parents, participants reported having to navigate professional identities at the borders of mathematics and statistics. Every participant was viewed by other teachers—the colleagues who would know them best—as a statistics teacher, and sometimes additionally as a mathematics teacher depending on the specifics of their school. On the other end of the spectrum, parents—who would be expected to be less familiar with participants than teachers or administrators—largely viewed them as

mathematics teachers, reflecting a limited understanding of the differences between mathematics and statistics. Administrators had mixed perceptions of participants, often recognizing them as both mathematics and statistics teachers. A primary reason for this recognition as statistics teachers is that participants had specialized knowledge that was useful for helping others with both teaching and research.

Major Contributing Factors

To explain why participants had different mathematics and statistics teaching identities, major contributing factors were explored. Two such factors are described here, teachers' specialized knowledge and their isolation as statistics teachers within a school.

Specialized Knowledge. Within their schools, participants were able to use their specialized statistical knowledge to support their colleagues' teaching. This support was often in the form of extended collaborations between courses or more focused teaching support to help individual teachers. Environmental science provided opportunities for robust collaboration with colleagues for two participants in this study. Early in his statistics teaching career, Louie co-taught AP Statistics along with AP Environmental Science; this collaboration served both courses by incorporating the collection of real data with a meaningful context which could be analyzed and interpreted appropriately using statistical tools. Similarly, Samuel is in the early-phases of a collaboration with an English teacher at his school to link AP Statistics with an environmental literature course that is being taught. This connection between statistics and environmental science is not isolated to individual schools. While not a local collaboration with an individual teacher as in the cases of Samuel and Louie, Patricia has presented workshops nationally about integrating AP Statistics and AP Environmental Science. Such collaborations with statistics are long-term and are a benefit to both halves of the partnership.

Other collaborations address more immediate statistical teaching needs of teachers. After conversations with the AP Biology teacher at his school about how best to teach statistical topics such as the chi-squared test in response to changes in the curriculum, Bob was invited into the science classroom for several years to teach that material. Additionally, because of the new emphasis on statistics in the AP Biology curriculum, Bob worked closely with that teacher to ensure that he was comfortable teaching statistics. Bob recounts, "I spent almost 4 years working with him to get his stat up to the point where he's comfortable doing that now so I don't have to go in [to his class] anymore" [Bob:325-327]. While Bob's work with the biology teacher spanned several years, its focus was more limited in scope than a partnership between two courses as above. Still, Bob was being consulted for statistical expertise that many mathematics teachers would not have.

Addressing immediate needs of teachers is not limited to helping science teachers. Rebecca has helped algebra teachers with statistics material that is included in the CCSSM such as regression analysis and residuals. This type of assistance can range from offering out-of-class descriptions and help with specific problems to co-teaching lessons and offering question-and-answer sessions in-class for students. Rebecca recounts:

> We co-teach [because] with the students you know they feel they can ask questions that she may or may not be able to answer as in depth, and then I have another teacher that asked me about residuals. We co-taught residuals together for a day. [Rebecca:506-508].

Part of the reason that Rebecca welcomes questions from her colleagues about statistics is that the asking of such questions reveals that they are trying to teach the material rather than skipping it. She says, "Several of them come to me with stats questions, it's in the Common Core units that they have, which is [why] I welcome that because that means that they are teaching the units" [Rebecca:287-288]. In response to curricular changes such as the CCSSM or updates to AP Biology, additional statistics content beyond what these colleagues of the participants have been prepared to

teach are required; statistics teachers are being consulted specifically–rather than mathematics teachers–because of their specialized knowledge and the different roles they serve within a school.

Isolation in Schools. Perhaps unsurprisingly, many of the teachers in this study reported being the only statistics teacher at their school, and also reported that this was also the case for many colleagues they knew. To address this situation, the exemplary statistics teachers sought out a different community from the school mathematics community. For Rebecca, her isolation was unlikely to change in the immediate future:

> I'm the only person at my school that's been to the training for AP Statistics, and I'm probably one of the only ones that really wants to teach it. There's not too many people that really like statistics [Rebecca:13-15]

Patricia began teaching statistics because "when [AP Statistics] first came out nobody else wanted it, so I just kind of fell into it" [Patricia:28]. When colleagues are not prepared and express no desire to teach a course, an isolated teacher can have difficulty even finding another teacher to discuss ideas with. As described by Amber, teachers of mathematics courses generally do not have this problem:

> One of the first challenges was not having anyone to be a soundboard for you. You know, 'What do you think about this? You think this might work?' … like where you have in algebra or precalculus there's going to be multiple teachers–you can work together. Having to work in isolation was really difficult in terms of teaching statistics. [Amber:231-234]

Participants cited not having "that regular opportunity for collaboration" [Paul:407] within their schools and the ensuing challenges as a reason for engaging with the broader statistics education community. Engaging with a professional community was a major contributing factor to the development of the participants' professional statistics teaching identities.

Discussion and Conclusions

The exemplary statistics teachers in this study developed professional identities as both mathematics teachers and statistics teachers. Depending on the specific context of an interaction, one professional identity may be brought to forefront. The effect of this is that the exemplary statistics teachers are continually working at and across the border between mathematics and statistics, even for teachers who only teach statistics classes.

The participants in this study had many years of teaching experience and had grown comfortable operating with these contextual professional identities and were able to use their specialized knowledge to serve their colleagues as a resource. Mathematics teachers who are less experienced with statistics, however, may not be so comfortable. The participants in this study each took several years developing their professional statistics teaching identities.

Improvements should be made to the statistical preparation provided mathematics teachers. Such recommendations are not new (CBMS, 2012; Franklin et al., 2015), but the experience of these exemplary statistics teachers provides further support for these calls. Participants in this study generally reported not feeling prepared to teach statistics when they were early in their careers. None was specifically trained to be a statistics teacher, and developing a statistics teaching identity required engaging with colleagues beyond their local school.

Participants found it critical to be connected with a broader community because they were often so often isolated, being either the only or one of only a few statistics teachers. Many of the participants reported that participation in the AP Statistics Reading or the AP Statistics Teacher Community (formerly the AP Statistics Listserv) provided initial and on-going experiences that helped them become exemplary teachers. Unfortunately, no direct analogues for either the AP Statistics Reading or AP Statistics Teacher Community exist for non-AP Statistics teachers at the 6-

12 level. Addressing teacher isolation within schools by connecting statistics teachers (particularly those new to the subject) with broader communities—either virtual or in-person—may be a viable approach for supporting teachers' transitions and growth. Teachers could be directed to such resources while they are still in their preparation programs.

Mathematics teachers who are being asked to teach more statistics now in grades 6-12 under the CCSSM (NGA & CCSSO, 2010) are likely to require different preparation and professional development than is required for mathematics. However, administrators, other teachers, and parents—groups who could conceivably support new statistics teachers—may not know enough about the disciplinary and instructional differences to recognize that additional, different supports are needed.

Asking mathematics teachers to teach statistics is more than simply asking them to teach new or additional mathematics material. Rather, because of widely-acknowledged disciplinary differences between mathematics and statistics (e.g. Cobb & Moore, 1997; Moore, 1988; Rossman et al., 2006), mathematics teachers are being asked to cross the border between mathematics and statistics. There are many potential benefits for teachers and students that may arise from this arrangement, e.g. new avenues for teaching quantitative literacy (Scheaffer, 2003; Steen, 2001) and changes in mathematics teaching practice. However, the complexities of the identities of these exemplary statistics teachers suggest that purposeful reforms to teacher preparation and professional development must be made and cannot be done in ways that recognize only the professional mathematics teaching identity.

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