ACCOUNTING FOR TEACHERS' INSTRUCTIONAL REALITIES WHEN SUPPORTING THEIR PROFESSIONAL DEVELOPMENT IN STATISTICS

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In this paper we analyze a design experiment aimed at supporting the professional development in statistics of twelve middle-school teachers in the United States. We explain how adopting a sociocultural framework allowed us to account for teachers' struggles to make sense of instructional practices in statistics that place students' reasoning at the center of instructional decision-making. We also account for how the adoption of the sociocultural framework allowed us to envision a viable way in which to better support the professional development of the participating teachers.

INTRODUCTION

A key step in the process of developing new statistical curricula consists of supporting teachers to incorporate the designed innovations into their professional practice. This step is nontrivial since it is common for developers to obtain only limited success in achieving this goal, or even to fail altogether—particularly when the incorporation of the new curriculum involves making students' statistical reasoning the center of instructional decision-making (Gravemeijer, 2004). In this paper we discuss what adopting a sociocultural framework affords when making sense of teachers' struggles to incorporate new statistical curricula, and when supporting them to change their practice. We do so by building on a research experience centered on supporting the professional development in statistics of twelve middle school teachers (serving children between ages twelve and fifteen) in an urban district located in the southeast of the USA.

BACKGROUND

Our collaboration with the teachers was based on a professional development program consisting of work-sessions and summer workshops. The work-sessions took place six times during the school year, and lasted about five hours each. The summer workshops lasted three days of six hours each. The events we refer to in this paper took place during the third year of our collaboration with the teachers. At that time, half of the teachers had been in the professional development program since the beginning, and half joined the group that year.

An important goal in our collaboration with the teachers was to support them in improving their statistical teaching by making students' statistical reasoning an important aspect of instruction. To achieve this goal, we tried to help them appropriate an instructional proposal for the teaching of statistics in the middle grades that was developed in a prior research project (Cobb, 1999). This proposal involves several innovative aspects when compared to typical statistical curricula in the USA. For instance, the core of the proposal is a domain-specific instructional theory comprised of conjectures about both (a) possible paths for communal statistical learning, and (b) the means that might be used to support and organize that learning (Cobb, Stephan, McClain, and Gravemeijer, 2001; Gravemeijer, 2004). This trajectory is meant to provide a rationale for teachers to constantly adapt their statistical instruction to the particular circumstances of their classrooms, and to make sense of students' emerging statistical understandings and capitalize on them. Overall, the proposal involves placing students' statistical reasoning at the center of instructional planning and decision-making.

At a technical level, the proposal encompasses the enactment of lessons that typically start with data-generation conversations. In these conversations, the whole class clarifies the relevance of the real-life issue to be addressed (e.g., which of two drugs would best for physicians to prescribe to patients with high blood pressure), how the data was collected, and its pertinence for addressing the issue at hand. The lessons continue with small group work, where students use statistical software to analyze a data set, and write reports that address the situation at hand. In

this part of the lesson, a teacher is expected to identify the diversity of reasoning within the group, and to envision ways to capitalize on it in the following part of the lesson.

The last part of the lesson typically involves the orchestration of data-analysis conversations. In these conversations, students' solutions are compared and analyzed by the group with the intent of making significant statistical ideas a focus of discussion. Within the proposal, this part of the lesson is considered to be the main site for statistical learning to occur. As a consequence, data-generation conversations and small group work are judged to be productive when they contribute to the enactment of rich data-analysis conversations.

METHODOLOGY

Our collaboration with the teachers was part of a design-research project that consisted of a design experiment (Cobb, Confrey, diSessa, Lehrer, and Schauble, 2003), aimed at developing theoretical frameworks and educational applications useful for supporting middle-school teachers in changing their instructional practices in statistics. In line with the design experiment methodology, the project was based on the enactment of cycles of design and research (Gravemeijer, Cobb, Bowers, and Whitenack, 2000). A cycle started with the formulation of conjectures about a possible path in the professional development of teachers, and about the means that might support it. It continued with the use of the formulated conjectures in designing the professional development interventions, enacted in the work-sessions and workshops. These interventions were videotaped and audiotaped, and also documented in a set of field-notes. The final step in a cycle consisted of analyzing the events that occurred during the professional development sessions, for the purpose of assessing the viability of the developed conjectures. A new cycle then started with the formulation of revised or new conjectures that guided the ensuing professional development interventions.

In this paper we account for one of the research cycles. During this phase of the experiment we were supporting teachers in learning about the orchestration of data-generation and data-analysis conversations.

SITUATION

In the third year of our collaboration with the teachers, an important professional development goal was to support them in learning about what is involved in the careful planning and orchestration of both data-generation and data-analysis conversations, as conceived in the original proposal. We conjectured that, as teachers acknowledged the importance of considering students' thinking in planning and enacting these conversations, it would become normative within the community to want to learn about how middle school students reason statistically. We also conjectured that it would become legitimate to problematize current instructional practices, and to want to learn about how to incorporate the proposal to their instruction, as a means to improve students' statistical learning (Gravemeijer, 2004).

In preparation for the work sessions, the teachers were asked to enact statistical lessons with their students that involved orchestrating data-generation and data-analysis conversations, as well as having students work in small groups. Typically, at least two of the teachers would pair to teach and videotape the lesson. In the work sessions, the whole group would analyze the videotape and discuss the nature of the events in it. In these conversations, we tried to focus their attention on the diversity of ways in which students reasoned and on how this diversity could be the basis for addressing relevant statistical issues during a whole-class discussion, in a sensible way.

In the analysis of the work sessions with the teachers, it transpired that the image many of them were developing, of the purpose and nature of both types of whole-class conversations, significantly diverged from what the research team anticipated. In general, teachers seemed to attribute much importance to the data-generation conversations, but not so to the data-analysis ones. When the former were discussed, many teachers' made extensive contributions; they offered insights about how to conduct them, and also described events that happen in their classrooms during these conversations. In contrast, discussions about data-analysis conversations were short, with few teachers contributing, and with many of them mentioning that they did not have time to enact this part of the lesson.

Many of the teachers seemed to have an image of the data-analysis conversations that involved students presenting their small group work to the whole class, in a *show and tell* fashion. None of them seemed to consider these conversations as a site in which to support students' statistical learning, as we hoped they would. Instead, they seemed to view it as an occasion for students to make public their small-group work. And although some of the teachers appeared to value learning about students' diverse ways of reasoning statistically, they only seemed to be interested in it for assessment purposes. In these work sessions, the teachers did not seem to share our view about students' reasoning being a resource that can be capitalized upon for discussing significant statistical ideas in a classroom.

RESEARCHERS' RESPONSE

In terms of our professional development agenda, the analysis of the work-sessions suggested that the originally developed learning-conjectures were unviable. As a consequence, we engaged in a research endeavor aimed at documenting teachers' *instructional realities* (Zhao, 2005; Zhao, Visnovska, and McClain, 2004). In this endeavor, we adopted a sociocultural perspective.

Our primary goal in this phase of the research project was to develop tentative accounts of the normative ways in which the purpose and nature of teaching statistics was construed within the teachers' labor community. We expected these accounts to give us insight into why the teachers construed the data-generation and data-analysis conversations in the way they did, and to help us envision an alternative path by which to support their professional development. Such a goal was analogous to developing what Simon and colleagues call *accounts of practice* (Simon and Tzur, 1999), since it encompassed articulating both what teachers do and the rationale that guides their actions. By taking this orientation, we assumed that teachers' interpretations of the data-generation and data-analysis conversations were reasonable and coherent within their ways of understanding teaching, and not the result of their possible limitations to understand our instructional proposal, or of their unwillingness to incorporate it into their practice.

Our accounts of teachers' instructional realities differed from those developed by Simon and colleagues in that we approached teachers' practice as being situated within the institutional context of their schools and school districts (Cobb, McClain, de Silva Lamberg, and Dean, 2003). We considered that teachers' views and actions were strongly influenced (though not causally determined) by their participation in a labor community and, as a consequence, by the institutional dynamics of the schools and school district in which this community existed. Our inquiry then centered on documenting our collaborating teachers' views of teaching statistics, as situated within the sociocultural world in which they exercised their profession.

It is worth emphasizing that our primary motivation in documenting teachers' instructional realities was to develop accounts that could support our professional development interventions. We adopted a sociocultural approach because—based on previous research (e.g., Spillane, Halverson, and Diamond, 2004)—we considered that it would give us leverage in envisioning how to help teachers change their understandings about the purpose and nature of teaching statistics in middle school. In addition, we tried to make sure that our accounts of teachers' practice were useful in guiding professional development. Such a focus on usefulness is not always valued in naturalistic studies where *consistency*, *depth*, and *accuracy* are considered more important.

We documented teachers' instructional realities by conducting twelve *teaching sets* (Simon and Tzur, 1999). Each set consisted of observing a teacher conduct a statistics lesson and then interviewing her. In the interviews, emphasis was placed on documenting the instructional rationale that guided the teacher during the lesson, particularly with regard to students' statistical learning, and to what they expected from each part of the lesson. The teaching sets were latter analyzed using an adaptation of Glaser and Straus' constant comparative method (Cobb and Whitenack, 1996; Glaser and Strauss, 1967).

TEACHERS' INSTRUCTIONAL REALITIES

In the analysis of the teaching sets we noticed that teachers would not readily develop accounts about the learning processes of students. The teachers seemed to view these processes as

part of a *black box* that mediated between their instructional efforts and students' outcomes. It seemed that thoughtfully orienting students' learning-processes was not something they considered possible for a teacher to do.

These views about students' learning seemed reasonable when considering the professional duties these teachers felt obliged to fulfill. They were accountable for teaching a relatively large number of students by implementing mandated curricula at a certain pace. Under these conditions, the teachers could have reasonably considered keeping track of how students learn as an unattainable goal, and also something that, if pursued, could jeopardize the fulfillment of important teaching duties.

For the teachers, the burden of academic achievement was on the students' side, and was mostly dependant on students' inherent qualities (e.g., their IQs), and on the quantity and quality of their engagement in instructional activities. For several teachers, this consideration was confirmed by their awareness about the same classroom instruction often leading to significantly different learning outcomes.

In the analysis of the teaching sets we identified two main aspects of teaching that were normatively valued within the labor community. The first centered on assuring that students were provided with sufficient opportunities to be able to develop the skills and acquire the content knowledge prescribed in the curriculum. Teachers tried to provide these opportunities in different ways. Sometimes they presented students with several kinds of graphical representations, or provided them with manipulatives. In the interviews, several teachers expressed an appreciation for using the statistical computer tools because, for them, it granted students opportunities to visualize statistical concepts.

Other times, teachers' efforts involved providing students with sufficient problems of a certain kind, as well as time to practice them. Several of the teachers mentioned how they would take apart mathematical concepts and procedures during instruction, in an attempt to make it easier for students to grasp them. The following excerpt illustrates the way in which teachers described their efforts to provide students with opportunities to acquire mathematical and statistical knowledge:

> Rachelle: [When my students are experiencing difficulties, I] descale [the problem], break it down, and let them know 'yes, there are rules and once you do enough of the problems you can generate your own rues or you pick up on [these] rules." (…)
> Interviewer: How could you tell if this kind of approach is helping the students or not?
> Rachelle: Usually, after they do enough problems, they visually [see] that "I don't have to go through this process, I know there are only gonna be two left." … it comes after they do enough problems with it. They have enough exposure.

The second identified aspect of mathematical teaching that was normatively valued within the teachers' community was that of making sure that students would attend to the provided learning opportunities. A primary instructional goal for teachers was then to ensure that students earnestly engaged in instructional activities. In the observed lessons, teachers constantly reminded students about the importance of paying attention. During the interviews, some of the teachers described how they tried to arrange their instructional time so as to obtain students' compliance.

For the teachers, a key instructional asset was students' willingness to cooperate. They regarded it not only as a premise but also as a precursor for learning. Sometimes they would offer students rewards in exchange for cooperation, such as permission to play games in the classroom computers, to surf the Internet, or to have free time. Noticeably, teachers' accounts about their attempts to engage students almost never involved adjusting core aspects of a lesson-plan.

Despite the many strategies described, teachers seemed to consider that they had limited agency over students' willingness to engage in mathematical activities. They viewed motivation as the key determinant of students' engagement or lack there-of. The following excerpt illustrates the teachers' normative view about motivation at the time when the teaching sets were conducted. It shows how, on the one hand, they construed motivation as a precursor of learning and, on the other hand, as something intrinsic to students and over which they had little control.

> Ben: …it's not that the concept is that difficult. It's that they chose to tune out and then didn't hear the end, didn't care… The biggest problem is motivational, and paying attention in class… The difference between [various instructional] methods in terms of the outcomes of the kids' understanding are not big compared to the difference between a kid that's unmotivated and a kid who is motivated. The kid who is motivated is gonna get it no matter which way you teach it… And it's very frustrating and difficult, it's incredible how hard it is to motivate the kids. All the standard motivators for a big chunk of my kids don't matter. I mean grades, disciplinary stuff.

In the analysis of the interviews it was also noticeable that the teachers used students' motivation as a predictor of learning outcomes. Several of them referred to motivation as being an index for anticipating if instruction would be effective with certain groups. These views were not surprising given that engagement was an important aspect of how teachers were assessed by school authorities.

In terms of our professional development agenda, the analysis of the teaching sets helped us understand the teachers' ways of making sense of the data-generation and data-analysis conversations, and of the small group work, as well as to comprehend why our original conjectures were unviable. We realized that teachers made sense of the different parts of the enacted statistical lessons in ways that fitted with their normative views about the purpose and nature of teaching and that, by doing so, the instructional values they recognized in the different parts of the statistics lessons were significantly different to the ones that originally guided their design.

We noticed that teachers valued the data generation conversations because the scenarios of the statistics activities were usually appealing to the students and therefore—from the teachers' perspective—helped to evoke students' engagement in the instructional activities. In other words, the teachers seemed to view the data-generation conversations as an effective way of *sugar coating* a lesson. As for the small group work, teachers seemed to value it because it was an opportunity for students to grasp statistical knowledge, and it was not hard to keep the class on task.

In contrast, the teachers found limited instructional value in the data analysis conversations. For most of them, this part of the lesson was little more than an opportunity to cultivate in students an image of themselves as capable statistical learners by having them present their work to the whole class. The analysis of the teaching sets also suggested that the teachers appreciated homogeneity in students' reasoning, particularly when it involved achieving a prescribed learning objective. As a consequence, it was counterintuitive for them to construe students' diverse ways of reasoning statistically as a valuable instructional resource.

DISCUSSION

The analysis of the teaching sets was significant because it helped us account for the unviability of our initial professional development conjectures. Our goal of readily focusing the professional development sessions on issues concerning students' statistical reasoning was not only inconsistent with teachers' common instructional practices; it also seemed to conflict with the normative ways in which they understood the purpose and nature of the work they were expected to perform.

The analysis of the teaching sets also allowed us to envision an alternative path for supporting teachers' professional development. We conjectured that, if we made issues of student engagement and motivation the focus of the sessions with the teachers, we could be more successful in advancing our professional development agenda. Briefly, in the alternative path, we anticipated perturbing teachers' normative views on students' motivation, as something that is mostly dependent on factors that are external to instruction. We conjectured that, in the long run, we could support a shift in teachers' views that would involve considering students' understandings of the mathematical and statistical ideas included in an instructional activity as strongly influencing the quality of student-engagement. Learning about students' reasoning would then become, for the teachers, a worthwhile endeavor.

The preliminary analysis of our following collaboration with the teachers suggests that the alternative professional development path was viable. It became normative in the group to view students' reasoning as a key aspect of statistical instruction. In addition, the teachers came to consider it important to adapt and incorporate the proposal for teaching statistics (developed in the classroom design experiment) to their practices.

FINAL REMARKS

In our research project, we faced the challenge of making sense of why a group of teachers construed an instructional proposal for the teaching of statistics in ways that significantly diverged from what we intended. Teacher educators and instructional designers frequently face this challenge. In our case, we conducted an inquiry on teachers' instructional realities, where we framed their doing and thinking as coherent, and as situated in the practices of the labor community to which they belonged. This orientation afforded us to develop a useful explanation of teachers' instructional struggles, and to envision a path for supporting their professional development that, at its starting point, was consistent with their views about the purpose and nature of teaching.

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