SUPPORTING SHIFTS IN TEACHERS' VIEWS AND USES OF PROBLEM CONTEXT IN TEACHING STATISTICS[1]

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We report on our 5-year collaboration with a group of teachers whose statistics instruction initially concerned producing graphs and calculations. Towards the end of the collaboration, the teachers routinely planned for statistical activities in which generation and analysis of data were driven by a need to gain insight in a specific problem at hand. We document the shifts in the teachers' views of the role of problem context in statistical activities and the means of support.

INTRODUCTION

Pedagogical practices that aim to support students' development of inferential reasoning are underpinned by a view of data as *numbers with a context* in which "pattern and [problem] context are inseparable" (Cobb & Moore, 1997, p. 803). Yet, curriculum documents and assessments are often based on a different view, in which problem context remains largely peripheral to an overriding focus on statistical tools. The contrast between these two views of statistical activity has implications for the design of teacher professional development (PD) sessions in which facilitators strive to make the statistical content relevant to teachers' current instruction while simultaneously promoting shifts in their reasoning and improvements in their classroom practices. This was the case during a 5-year PD collaboration that we conducted with a group of middle-school mathematics teachers in the USA. The teachers' statistics instruction was initially typical in the US context and focused on graphical conventions and calculations (Dean, 2005). In contrast, towards the end of the collaboration, the teachers planned for activities in which the generation and analysis of data were driven by a need to make specific decisions or judgments. We summarize the changes in the teachers' statistical reasoning and outline the means by which these changes were supported. In particular, we highlight how examining the role of problem scenarios during the PD sessions contributed to shifts in the teachers' views of a productive classroom statistical activity. We argue that problem context, which resides on the crossroads of different pedagogical considerations, provides a space for building from teachers' current instructional practices towards PD goals.

BACKGROUND TO THE PROFESSIONAL DEVELOPMENT DESIGN EXPERIMENT

We draw on the PD design study (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003) that we[2] conducted with the group of 12 teachers in a diverse urban district with a high-stakes accountability program. We conducted 8 to 9 full-day sessions per year. We aimed to support the teachers in (a) deepening their understanding of central statistical ideas, (b) making sense of individual students' statistical solutions, and (c) adapting instructional sequences developed in prior classroom design experiments to their classrooms. Our question concerned the process of supporting development of practices in which students' reasoning is central to instructional decisions.

The instructional sequences were designed to support instruction in which a context-specific question orients data collection and analysis, and where identified patterns in data have to be justified in terms of the question at hand. Our intent was to engage teachers in activities that would enable them to reconstruct the rationale for the instructional sequences, and thus facilitate adaptation of the sequences to their classrooms. It was therefore key that as part of their learning, teachers would come to view statistical activity as inherently involving numbers with context.

During the third and fourth years of the collaboration that are the focus in this paper, the PD activities typically followed the pattern of teachers (a) solving a selected task from the statistics sequence during the work session, (b) teaching the same task with their students, and (c) bringing students' written work to the following work session for analysis and group discussion. In addition, we frequently video-recorded two of the teachers co-teaching a lesson using the same task, and used the recording as a focus for group discussion in the following PD session. Our overarching

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goal in these sessions was to support the teachers' development of a long-term learning trajectory for supporting the development of their students' statistical reasoning.

DATA SOURCES, AND METHOD OF ANALYSIS

Data consist of videotapes of PD sessions in the years 3-5 of our collaboration accompanied by a set of field notes, copies of all teachers' work, and classroom videotapes of their statistics instruction. We analyzed the patterns and regularities in the ongoing interactions of the group (Dean, 2005) to identify shifts in teachers' pedagogical reasoning as they participated in PD activities across time. The specific approach to analysis involved a method described by Cobb and Whitenack (1996). This approach was developed for analyzing longitudinal data sets that are generated during classroom design experiments. Tentative conjectures are continually tested and revised while working through the data chronologically. As new episodes are analyzed, they are compared with currently conjectured themes or categories, eventually resulting in the formulation of claims or assertions that span the entire data set but yet remain empirically grounded.

THE END POINTS AND THE STARTING POINTS OF THE TEACHERS' LEARNING

Our work with the teachers during year 5 was designed to be a performance assessment, the goal of which was to understand what the teachers had learned in the course of the PD sessions conducted during the prior four years. The teachers' goal during year 5 was to develop statistics instructional unit to be used in their school district. They first reviewed and critiqued two sets of instructional units in statistics and then selected tasks from these units that they found the most suitable for their needs and organized them into an instructional sequence. One set of units comprised an NSF-funded textbook series that the district had adopted in that year. The second set of units was based on the statistics instructional sequence used in the PD that was designed by the teachers at additional research site in a different state. We continued to support the teachers' participation in year 5 but we provided considerably less press for them to align with our PD agenda.

The teachers' participation in year 5 indicated that they came to expect that a statistical task would enable students to gain insight into an important problem. It is significant that 23 out of 38 critiques of tasks that the teachers raised during the last 2 review sessions in year 5 pertained to the statistical purpose of tasks and to the significance of the problem at hand. A further 7 critiques identified either the specific question asked or the data generation process as problematic. When the teachers compiled a list of key instructional issues during the final 3-day summer institute, they included "connect[ing] data to situation" and "making decisions based on data." They proposed that learning statistics "in the situation" should be an overarching goal. These findings indicate that the teachers came to treat problem scenarios as an inherent aspect of statistical activity.

We now illustrate the views of a classroom statistical activity that were normative in the group in year 3 by focusing on initial phase of a lesson that the teachers referred to as the *launch.* An initial discussion in which the teacher and students talked about the *purposes* for generating data and the *ways* in which data could be generated had proved effective during classroom design experiments. We viewed these *data generation discussions* as occasions in which teachers could renegotiate the nature of classroom statistical activity by providing their students with both reasons and means for engaging in data analysis. We viewed these discussions as inherently statistical since insights in data generation process enabled students to address realistic problems statistically.

When the teachers planned for and introduced the activities in their classrooms during year 3, it became evident that they viewed the launch primarily as means of fostering their students' engagement and to help their students understand what they were supposed to do to complete the task. Crucially, their launches typically did not make explicit the need to resolve a significant issue that extended beyond the collected data and did not include a discussion of the data generation process. The episode from session 2 of year 3 is representative of the teachers' understanding of the purpose of the launch at that point. In the *Watermelon* activity, students were to compare data on weight of watermelons from two different distributors (10 watermelons from each). The goal was to advise a restaurant owner about buying watermelons for making juice, given that price per watermelon was the same. In their launch, Naomi and Marci held long discussion about kinds of juices that students liked and then distributed printouts of data that the students were to analyze.

When the teachers viewed the video-recording of this launch, they constituted it as effective because all students in the video "[got] involved in what's going on" and "[bought] into" the activity. The teachers argued that the students would become engaged as a result of discussing juices they liked because they were able to share their opinions and would feel included. They did not propose additional expectations for the launch and waited to see, as Brian had put it, "where was the math gonna be in all of this." Brian's comment indicated that he did not expect the launch to help him (and his students) understand what data needed to be generated. Instead, the goal of the launch was a non-statistical precursor designed to "hook" the students, after which they could be given the data and told the problem they were to address. Nonetheless, the teachers' interest in facilitating launches that they considered effective provided leverage for their subsequent learning.

FOCUSING ON PROBLEM SCENARIOS AS PART OF A STATISTICAL ACTIVITY

We need to describe the additional goals for teachers' learning that we pursued in order to situate the shifts we documented in the teachers' views of a statistical activity. During the 3-day summer institute at the end of year 3, we capitalized on the teachers' concerns about engaging "unmotivated" students by developing a sequence of activities designed to support the teachers in (a) coming to view students' motivation as situated with respect to the nature of their instruction and thus within their control, and in (b) coming to view the cultivation of students' statistical interests as an important goal of instruction (cf., Dewey, 1913/1975). These activities proved to be reasonably effective, and it became normative in the group to adopt a student's point of view when anticipating which types of problem scenarios were likely to capture students' interests. This shift proved to be critical in establishing productive criteria within the teacher group for what constituted a good problem scenario. The normative views of which aspects of scenarios and launches could cultivate students' interest in analyzing data evolved over time. These aspects came to include both the significance of the problem at hand and the quality of the data generation process. As the teachers established the importance of these aspects while they investigated cultivation of students' interests, their overall view of what constitutes a productive statistical activity shifted.

Good Problem Scenarios are Aligned with Students' Prior Personal Experiences

In year 3, the teachers assumed that enjoyable or "fun" scenarios had the best chance of engaging students. In contrast, at the beginning of year 4, all but two teachers proposed that in order for an instructional activity to be of interest, students needed to have a *prior personal experience* with the topic at hand. This view was evident during session 2 of year 4 when the teachers participated in data analyses as students. They analyzed data on the braking distances of cars and of trucks (i.e., lorries) in order to advise a police department about whether highway speed limits should be lower for trucks than for cars. This scenario was introduced as an issue of road safety. In the discussion that followed, the 7 teachers who spoke up all explained their interest in the activity in terms of the personal relevance of the topic at hand, and all but one conjectured their students would not be interested in classroom activities grounded in similar scenarios because they did not have the requisite personal experience. As a result, most of the teachers did not consider that topics of broader social significance would be interesting to *their* students. This view contrasted with the data from the classroom experiments where scenarios of this type proved to be the most productive with a similar group of students (Hodge, Visnovska, Zhao & Cobb, 2007). Nevertheless, it was critical that in articulation of their assumptions, the teachers adopted a perspective of a student (not of a teacher). This made it possible for them to test these assumptions when they enacted the statistical activities in their classrooms and to seek alternative explanations when the students have—contrary to the teachers' expectations—become interested in scenarios that dealt with road safety.

Good Problem Scenarios Should Address a Significant Problem

The shift in the teachers' views about appropriate scenarios became apparent during session 5 of year 4. We engaged the teachers as learners in a launch in which we discussed the significance of a problem in detail. Coincidentally, the teacher who brought his classroom-video recording for the group analysis had not addressed the significance of the task in his launch. Several teachers pointed out the contrast in the two launches, and clarified that if students came to see the problem at hand as significant, they might develop a need to analyze the data. Seven out of the 10 teachers who attended the session mentioned the importance of discussing the significance of the problem at hand with students in their written reflections at the end of the session. The two statistics lessons that were co-taught and video recorded after this session both included a discussion of the significance of the problem in the launch. In addition, four out of the 12 teachers present in session 6 of year 4 commented that they now actively worked to help their students appreciate the significance of the problem, rather than expecting students to relate to the scenario at the outset. The group subsequently developed a way of talking about the significance of problems as *the broad issue that helps students develop reasons to engage in the problem* (e.g., road safety) and specified that this broad issue needs to be *narrowed down* in the launch *to a specific question that can be analyzed statistically* (e.g., whether trucks have greater braking distance than cars). The issue that initially emerged as one of supporting students in becoming interested in a statistical activity now included considerations that were inherently statistical.

A Good Launch Includes a Discussion of the Data Generation Process

In session 5 of year 4, we engaged the teachers as learners in an intentionally inadequate launch in which we discussed the significance of the problem but omitted a discussion of the aspects of the situation that needed to be measured and how the data might be generated by making measurements. When we introduced the data and asked the teachers to analyze it, they bombarded us with questions about the data generation process. In the activity and conversation that followed, the role of data generation discussions in both (a) making it possible for students to analyze data and (b) supporting learners' interest and engagement *while they analyzed data* became apparent. One issue that came to the fore was the distinction between answering questions about data that had already been generated, and conducting a collective thought experiment with students in the classroom in which decisions about what data to collect and how to collect them had to be justified. In the following session, 5 teachers shared that they had unintentionally skipped the thought experiment and that the omission had negatively impacted their students' work. At this point, the need to include a thought experiment no longer required justification. As a consequence, the initial phase of lessons now included further considerations that were inherently statistical.

CONCLUSIONS

In supporting teachers' development of increasingly sophisticated views of statistical activity, problem context is not only relevant but can provide a basis for renegotiating what counts as effective classroom instruction. At the outset, the teachers were concerned about motivating their students and viewed problem scenarios as tools for doing so. We capitalized on these concerns to support them in beginning to adopt the perspective of a student when assessing the effectiveness of classroom instruction. Investigations and discussions in which the teachers adopted this perspective enabled them to understand how they could proactively support their students in becoming and remaining interested in analyzing data. This in turn shaped the teachers' views of effective statistical tasks and of the role of problem context in supporting students' statistical learning.

NOTES

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2. The research team included the authors, Kay McClain, Chrystal Dean, Qing Zhao, Teruni Lamberg, Melissa Gresalfi, Lori Tyler, and Jose Luis Cortina.

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