PROFESSIONAL DEVELOPMENT FOR TEACHING STATISTICS: A COLLABORATIVE ACTION RESEARCH PROJECT WITH MIDDLE-SCHOOL MATHEMATICS TEACHERS

Leandro de Oliveira Souza
Universidade Federal do Amazonas, Brasil
olileo@ig.com.br

Teachers need to develop many dimensions of their practice such as statistical knowledge, beliefs about statistics, designing their own lessons and adopting new teaching approaches. We developed a project named Teacher Professional Development Cycle in Statistics (TPDC) which involved sixteen teachers of Mathematics of the elementary school in a process of collaborative action research. The data were collected based on recording videos of meetings and on six questionnaires which were answered by the teachers during the project. The results showed that teachers worked collaboratively overcoming their feelings of insecurities about teaching statistics when an investigative and exploratory approach was used to improve their knowledge and conceptual content. This paper will present our description of how the TPDC project was designed, as well as the advantages in using it in teacher development.

INTRODUCTION

In Brazil, in 1998, the National Curriculum Parameters (PCN) suggested that statistics be incorporated into the mathematics middle school curriculum, and in 2002 statistics was prescribed for the high school level. The PCN presents teaching guidelines that aim to guarantee the right to a set of knowledge that is recognized as essential for the full exercise of citizenship in a society marked by social inequalities.

Despite curricular changes, we hypothesize that the main obstacle to implementation of statistics into schools is teacher professional development. The formal training of Brazilian mathematics teachers in their graduation courses and also the political difficulties in improving their knowledge in service hinders students' comprehension and understanding of basic concepts in statistics.

Teachers' beliefs imported from mathematics to statistics affect and act as a barrier in orientating students towards recognizing and handling uncertainty and variability. According to delMas (2004), if the conception of teaching statistics is immersed in a mathematics formalist approach, grounded on exercise from textbooks or taught as a tool to solve generical problems, then students will have difficulties in understanding basic concepts of statistics because the reasoning is different from mathematics.

Although recent research in statistics education has produced a huge quantity of knowledge and resources (Ponte, 2011), it has not helped to change the approaches and methodologies utilized by teachers in classrooms. Part of the problem is that teachers' experiences are mainly grounded in descriptive statistics and they are challenged by recent approaches, curricula, and guidelines for statistics teaching and learning (e.g., Franklin et al., 2005; Ministry of Education, 2007). Despite the fact that efforts has been made to put traditional practices away from statistics teaching by new curricular programs, orientations and researches, some paradigms still need to be overcome, mainly talking about how to teach statistical reasoning and how to develop new teachers' expertise.

Thinking on how we, as researchers, could assist teachers to appropriate the knowledge that has been produced in the statistics teaching area we asked: What type of professional development could assist teachers with multi-dimensional development needed to start acquiring expertise in teaching statistics in new ways, ways that aggregate value to student's reasoning, not to student's procedures?

Answers to this question are not so evident. Currently, Brazilian mathematics teachers glean their knowledge of statistics from textbooks and their own experience in university courses. To remedy the situation we conducted a small-scale research project to improve teachers' understanding of statistics and to teach statistics in new ways. In this paper we report on the use of our Teacher Professional Development Cycle (TPDC) project for teacher development in statistics education and its efficacy in providing teachers with some pedagogical concepts and content to

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face the new challenges in statistics education. Although we had a previous project designed, the initial project was modified while our teacher development program was going on, according to teachers' needs.

METHODOLOGY

The methodology involved in our investigation was the action research process, which is described by Barbier (2004) as a process conceived to facilitate intentional changes, decided by the researcher, in the practice of teachers. Although the researcher initiates the process of action research, the researcher actually works collaboratively with those involved. Actions are the priority in this sort of research, but the researchers explore the consequences of the action with the purpose of academic research. Tripp (2005) describes four types of action research in which people can participate: obligation, co-optation, cooperation and collaboration. We chose to investigate through a process of collaboration in which people work together as co-researchers in a project where everyone has equal participation. According to Barbier (2004), action research begins in the context of a group in crisis, since researchers cannot provoke a problem. The problem of teacher development in statistics was provoked by statistics being newly introduced into the Brazilian curriculum. We aimed to assist all involved to become aware of the most important concepts to be taught in statistics so that they could take collective action in improving their practice.

Sixteen teachers volunteered to participate in our research project after an invitation was sent to 80 teachers. These teachers at the time were working in schools under the government of the city of São José dos Campos, São Paulo, Brazil. Twelve of the teachers we classified as experienced (>5 years teaching), whereas the other four teachers were classified as novices. To conduct our research, eleven two-and-half meetings were scheduled during HTC[1].

In the first meeting, we collected data through an initial questionnaire that aimed to help us understand the professional experiences that teachers had in teaching and learning statistics, and also their experience of this subject in their undergraduate courses. Furthermore, we aimed to know what sort of teaching approaches they were currently using in their classrooms. The other five questionnaires were spread over the 10 meetings with the final questionnaire focusing on a self-assessment of the approaches utilized by teachers in their lessons about how they were feeling in regard to teaching statistics using an inquiry process and what changes occurred in their practice as a result of being a member of the project team. All the questionnaires used open-ended questions with 20 questions in the first questionnaire and approximately 4 questions in each of the other questionnaires.

The meetings were divided into three phases – workshops, planning, and reporting –all of which were organized and facilitated by the researchers. The first phase consisted of four meetings organized as workshops in which teachers had their first contact with inquiry approaches and technological tools to teach statistics. The second phase was also organized into four meetings. In this phase we chose content that was randomly selected by the teachers who were organized in groups. After the content was selected, the teachers developed a lesson assisted by the researchers. Then they applied the lesson to a group of students and took notes on their observations in order to report their experiences to the whole group. In the third phase the teachers presented their experiences on what had been successful and unsuccessful in their approaches when the lesson was applied. We finished the last phase discussing what could be improved in their teaching of statistics and in their lesson.

In our research we were focused on reflecting, understanding and qualitatively analyzing how a collaborative group can develop strategies to overcome their limitations in their approaches to teaching statistics content. We were also interested in analyzing how changes occurred in teachers' practice. After each meeting we analyzed what had occurred using the data we had collected. This enabled us to plan the next meeting taking into consideration our purpose of assisting in creating a change in practice and in developing the next questionnaire. For our data analysis we used a method that would be described as thematic analysis (Braun &Clarke, 2006). It is "a method that works both to reflect reality and to unpick or unravel the surface of 'reality'" (p. 81) where the "theme captures something important about the data in relation to the research question, and represents some level of … meaning within the data set" (p.82). It is a six-stage method that starts with data familiarization, through the collation of data into relevant themes, to

finally selecting compelling extracts that provide a rich description of the data for a group of themes within the data which relates to the question of interest for the report.

TEACHER PROFESSIONAL DEVELOPMENT CYCLE PROJECT

The TPDC project was designed to provide facilitators with data from teachers' knowledge about their own practice on teaching statistics. Imbernón (2010) argues that there is a need to abandon the obsolete concept that teacher development is a scientific, didactic and psycho-pedagogical updating of knowledge; that there is a need to replace it with the belief that teacher development should be about helping teachers find out the theory and to reorganize, revise and reconstruct their knowledge. According to Imbernón, our TPDC project is based on the principle that teacher development should be managed as time for reflection and innovation, instead of time for updating, with the aim of preparing teachers to create new teaching approaches and also identify and face new problems. Our TPDC project (Fig. 1) comprises five phases of orientation, exploration, application, analysis and reflection, each of which will be discussed.

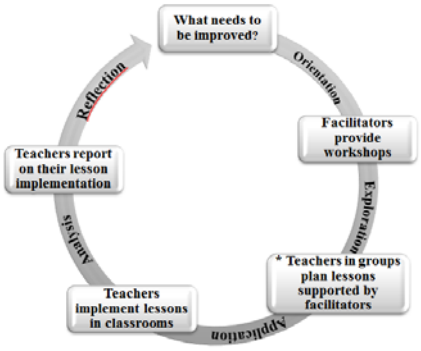

Figure 1.Teacher Professional Development Cycle project (TPDC)
*Component added in during research project

All these phases were embedded in our understanding of three main ideas: the three concepts pointed out by Ponte (2011), pedagogical content knowledge, specialized knowledge of content and professional knowledge; the models of Wild and Pfannkuch (1999) that concern the way one acts and what one thinks about during the course of a statistical investigation; and the Makar and Fielding-Wells model (2011) that concerns developing expertise in teaching statistical inquiry. However, it should be noted that the component in the exploration phase where teachers plan their own lessons was added during the research project in response to teachers' reactions when they were asked to implement a workshop activity with their class.

Most teachers do not seek educational research to support them in improving their approaches (Zeichner, 1998) because educational theory is seen as something that another person with more status and prestige theorizes about their classes (Elliott, 1991). The main reason for teachers' skepticism is the use of a specialized language in the academic environment that only makes sense to sub-communities of researchers. We consider skepticism as the first obstacle to be overcome in teacher development. Therefore, before beginning the orientation phase, teachers must be listened to; they must be viewed as a group that aspires to gain new knowledge and they should not be immersed in an environment of hierarchical relationships and subordination (Fiorentini, 2009). Teachers should be involved in the identification of problems and in assessing what needs to be improved in their approaches. On the other hand, facilitators (i.e., researchers, teacher educators, or professional development facilitators) must be responsible for connecting teachers' complaints with possible solutions or alternatives.

The orientation phase proposed by Makar and Fielding-Wells (2011) cannot be imposed by anyone else and must have at its base the experience and needs that teachers bring to the discussion. For example, much research has pointed to the efficiency in using technologies to teach statistics (Pratt, Davies & Connor, 2011), so facilitators may suppose that this is a good way to start a course. Although new technologies might be helpful in improving teachers' concepts, facilitators

cannot assume that teachers have access to technology at school. Each school and each teacher have different problems and different needs. Therefore, the orientation phase is a negotiation process between teachers who have professional knowledge and facilitators who have academic knowledge. The orientation phase has to be focused on supporting teachers to effectively analyze and adapt their own practices, including lesson content within the spirit of statistical inquiry.

Development of teachers cannot be regarded as training; consequently workshops provided by facilitators must not be lectures based around solutions for generic problems (Imbernón, 2010). The contexts where teachers develop education practices are fundamentally important and facilitators must take this into account in their planning decisions. In a continuous development process we believe it is necessary to promote teachers' autonomy if we hope that in the future they can manage and understand their own needs. Facilitators need to consider teachers' practice in order to improve their knowledge and educational theory, to provide them with opportunities to learn through the inquiry process and to resolve any problems associated with teaching students. For developing expertise it is also important that it be clear for all those involved that the interest is in what teachers do and not in what they say they do (Brown & Coles, 2011). That is why it is important to observe teachers' practices planning and working on their own lessons.

The exploration phase is the time when teachers and facilitators reflect together about how to enhance students' learning through the inquiry process. In the opinion of Garfield and Ben-Zvi (2008), the collaboration process promotes reflection on teaching when teachers verbalize and justify what is believed and practiced, which also leads teachers to question their own assumptions and actions . While teachers are trying to make connections between their planning of their inquiry lessons and the curriculum, they can ask the facilitator questions. The questions might result in the facilitator reflecting on how to help teachers to link their practical knowledge with the theory. Or when teachers are brainstorming during lesson planning, they may resolve their own questions. The facilitator should act like a partner and be involved in this process by assisting teachers to produce better materials, assessments, and teaching techniques and by building on the diverse backgrounds and experiences of the teachers in the group.

Although one planned lesson alone will not change teachers' practice, the phase of application is motivated and grounded by collaboration that supports teachers in making changes that may be daunting to try on their own. According to Garfield and Ben-Zvi (2008), teachers and facilitators acting together in a group encourage and provide an environment to reflect on these changes and hence move forward, rather than abandoning efforts when they are not immediately successful. It is important that teachers are prepared to identify the reasons why a lesson did or did not work well, as well as being aware that understanding mistakes is a normal phase of the teaching process.

The phase of reporting and analysis in the TPDC project involves formative assessment, a method that teachers do not traditionally use (Garfield & Franklin, 2011). Reporting requires from teachers a self-assessment of the lesson and an analysis of their students' reasoning. When teachers are assessing students' performance to inform other teachers, they are providing feedback on how effectively students were learning the desired material, and on how they might modify instruction if necessary. In the reporting phase both the facilitators and the other teachers can contribute with their own experiences, validating the process or assisting the teacher to reformulate concepts and the lesson. Also, when teachers are conducting the planned lesson, it is through the interaction with students that they become aware of new solutions to known problems and in this way they will develop new connections (Leikin & Zakis, 2007). The major concern of facilitators (Zaslavsky, 2009) in this phase should be the need to foster teachers' reflective practice.

The reflection phase of the cycle allows time to rethink, reflect and evaluate the process of development, and it is also the beginning of a new cycle. This program has no end; it must work as a spiral formative process. Moreover, it must go back and forth ever we need to understand theoretical issues and their pertinence in teaching.

CONCLUSION

Teacher development, according to Nacarato (2000), begins in childhood through students' first contact with the process of education. Models of teaching that were experienced by teachers throughout their academic life are resilient and may be copied particularly in the early years of the profession. Traditional approaches to teaching statistics and probability remain in our schools. The reproduction of approaches experienced in teachers' careers is shown in their practice and therefore it is important to continue teacher development. New approaches have been developed by researchers and hence continuous teacher development in statistics is needed as a consequence of changes in the curriculum and changes in the way that society appropriates new information. The TPDC project has the potential to provide teachers with concepts and content to start developing their expertise to face the new challenges in statistics education.

What we found is that one cycle of the TPDC project seemed to help teachers to start to change their view about the subject. It allowed them to understand some of the problems, which permeate their practice. The project facilitated discussions where connections between practice and theory were made to solve pedagogical situations. For some volunteer teachers, the engagement of their students in the lessons they designed was a pivotal moment in helping them to reflect on their current practice, a factor that was also identified by Makar and Fielding-Wells (2011) as important in teacher development. Consequently, from our observations and the teachers' discussion we predict that if we had more cycles, more teachers would become engaged.

Developing teacher expertise is a long process that needs to be supported until teachers can actively sustain their own development. Key elements in our project are: the creation of a supportive environment for a community of teachers; an orientation phase that not only takes teachers' needs into account, but also exposes them to new teaching ideas; teachers collaboratively planning their own lessons with facilitators actively challenging them; teachers implementing their own lessons and reporting back to the group on their teaching experiences; and teachers and facilitators having the opportunity to critically reflect on their practice, including identifying gaps in content knowledge. We believe that our TPDC project has the potential to assist teachers with multi-dimensional development needs, but further research in many different settings is needed toattest to its effectiveness.

ENDNOTE

[1]HTC in Portuguese means Time to Work Together. It is a period of 5 hours a week of study. It is non-obligatory. Teachers, in groups, discuss teaching approaches, projects and anything connected with education. Frequently HTC is used by Pedagogic Coordinators to develop teachers' pedagogic concepts.

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