PROFESSIONAL DEVELOPMENT PROGRAMS FOR STATISTICS TEACHERS: THE ROLE OF REFLECTION

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This article studies the role of reflection in the growth and transformation of the statistics teachers who participated in a professional development program. Statistics teachers from different school levels participated voluntarily in a professional development program which goal was to design statistics lessons and reflect on their implementation. Information was gathered from different sources to track teachers' growth about statistics and statistics teaching. Techniques such as autobiographies, journals, ideograms, reflective writing, and interviews were used. Lesson plans and recordings of the meetings complemented the sources of information. The results show that teachers' participation in the professional development program contributed to the evolution of reflection about statistics and statistics teaching.

PROBLEM AND BACKGROUND

Nowadays, statistics is a subject in most curriculums around the world but research has shown that most teachers do not feel comfortable teaching it (Nacarato & Grando, 2014) and do not feel strong enough in the subject (Rodriguez-Alveal, 2017). This could be because statistics teachers in several educational systems only are required to take one statistics course during their teacher education period (Zapata-Cardona & Rocha Salamanca, 2011) and most of those courses follow a formalist approach (Souza, Lopes, & Pfannkuch, 2015). Consequently, there is a strong need for research on *professional development* that helps statistics teachers and statistics teacher educators to identify the needs to be addressed and the good practices that contribute to the *professional development*. We understand professional development as a way of solving professional problems of the daily practice that implies a professional, social and personal growth (Vázquez-Bernal, Jiménez-Pérez, & Mellado-Jiménez, 2007).

This research is based on a program in which statistics and statistics teaching were the objects of study in teachers' practice. Statistics teachers gathered and collaboratively *reflected* on the statistics lessons they designed and implemented as well as on the statistical investigations they carried out. In our conception of professional development, reflection is essential and it is assumed as a metacognitive mechanism oriented to action in which the participant teachers question their own narratives about their practice before, during and after teaching (Hoffman-Kipp, Artiles, & López-Torres, 2003). Thus, teachers' reflection reveals the characteristics of teachers' practice and their implications. Likewise, teachers' reflection is an important contribution to the transformation and growth of the teaching practice (Vázquez-Bernal, Jiménez-Pérez, & Mellado-Jiménez, 2007).

In this research, we focus on fragments of teachers' discourse in the process of reflection to illustrate the evolution of teachers' views about statistics and statistical knowledge as the result of their participation in the professional development program.

THEORETICAL FRAMEWORK

In this section, we present some concepts and expressions that are central to understand the study and the development of our ideas. We describe our conception of professional development, then we present different dimensions of reflection and we end with a brief description of statistical investigations.

Professional Development

We conceive teacher development as a continuous process throughout life that takes into account the action of the teacher in the classroom —his/her practical knowledge—; a process that links knowledge of experience and reflection about teachers' daily practice. Professional development of statistics teacher has to start from the experience to go further. Coherent with this perspective of professional development, we conceive the teacher as a transformative intellectual

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that develops his/her professional knowledge from the experience (Zapata-Cardona & González Gómez, 2017).

Reflection in Professional Development

Reflection is a social construction oriented to the action and is essential in teacher professional development. It is "a process that is embedded in everyday activities situated in school cultures that are social in nature, where interactions with others are an important medium in which reflection occurs" (Hoffman-Kipp, Artiles, & López-Torres, 2003, p. 250). Teachers through questioning the narratives of their practice can set a favorable environment for change and growth. Several authors have stated the emancipatory action of reflection (Schön, 1983; Vázquez-Bernal, Jiménez-Pérez, & Mellado-Jiménez, 2007), which is essential to learn from the experience. We coincide with Vásquez-Bernal and his colleagues (2007) who stated that the conscious reflection supports the generation of theoretical and practical-contextual knowledge. They highlight that reflective practice looks at teaching as a personal process of inquiry that takes into account the tensions of a culture as a catalyst for the development of professional knowledge. Vásquez-Bernal and his colleagues consider three dimensions of reflection: technical, practical and critical. Each dimension is much more complex than the preceding one. The critical dimension of reflection presupposes a progressive evolution from the technical one.

> *Technical*: This dimension focusses exclusively on the skills and strategies related to the subject matter that the teacher needs to teach a topic. In other words, this dimension of reflection is concerned about the *knowing* and reduces teaching to dissemination of information. It focuses on implementing what teachers receive or develop in teacher education periods.
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> *Practical*: The core of this dimension is centered in solving practical problems, its focus is on developing the "know how". This dimension is concerned about using the technical knowledge to solve problems from the practice. The reflections about teaching are aligned with problem-solving.
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> *Critical*: This dimension is related to a political act that can contribute to a just and human society. It incorporates ethical and moral criteria for the development of auto critic, social justice, and awareness. Radford (2016) calls this the process of *becoming*. In this dimension of reflection, the goal is to develop a political awareness that helps teachers to integrate curriculum around issues of society (Hoffman-Kipp, Artiles, & López-Torres, 2003).

Statistical Investigations

Statistical investigations are holistic and practical ways of organizing the teaching of statistics (Zapata-Cardona, 2016). They are based on an investigative route (MacGillivray & Pereira-Mendoza, 2011); they include a whole process of identifying a problem of society (Skovsmose, 1999 calls them crisis) and developing the tools to study it empirically. The essence of the statistical investigations is to imitate the daily practice of professional statisticians (Pfannkuch, 2011), which is centered in solving real problems while developing knowledge, skills dispositions to understand and critically participate in the world (Campos, 2016). Statistical investigations center on questions related to the world. Scenarios like garbage production, index of human development, food production, climate change, environmental impact have a great potential to contribute to the social awareness (Stillman, Brown, Faragher, Geiger, & Galbraith, 2013). The most important aspect of statistical investigations is that they do not center exclusively on the *knowing* but on the social dimensions of the *beings* (Radford, 2006).

METHODOLOGY

In this study, ten schoolteachers of statistics, from different levels, got together with researchers ―every three weeks for a full semester― to design, discuss and assess statistics

lessons. Some of those lessons were implemented in the classroom of the participant teachers, which were audio, and video recorded. Teachers also had the opportunity to bring to the meetings statistical activities and materials to orient specific topics they were working on in their classrooms. Teachers also were engaged in solving statistical problems inspired by the *statistical investigations* that the researchers prepared. All the meetings were video recorded. The researchers purposefully selected video segments from the implementation of the lessons and from the professional development meetings, which were the main inputs to promote teacher reflection during the professional development program. Teachers' autobiographies, journals, ideogram, reflective writing, and final interviews were also important sources of information for the analysis. Data was gathered in that way to be coherent with Hoffman-Kipp and colleagues (2003) who state that "Teacher reflection is comprised of self-awareness often achieved through introspection-both in the moment and after-through journals, scrapbooks, or other re-positories of personal experience" (p. 249). The analysis focused on teachers' discourse, special attention was dedicated to those fragments in which they referred to the statistics and statistics teaching. The two researchers in this study went through the data, independently, to find those fragments of speech and then gathered to discuss the differences and to find agreement.

The statistical lessons were inspired by the *statistical investigations* (Zapata-Cardona, 2016). To illustrate the nature of statistical investigations, the researchers identify a problem of society and ask the participants to put the resources together to study it empirically. For example, participants were asked to answer the statistical question "is there equity in the salaries of actors and actresses in Hollywood?" The statistical investigation was completed with the activity "statistical evidence of discrimination" that was published by Scheaffer, Witmer, Watkins, and Gnanadesikan (1996).

RESULTS

In this component, we focus on fragments of teachers' speech that reveal their reflections about statistics and statistics teaching during the professional development program. We classified fragments of teachers' speech according to the three dimensions of reflection described in the theoretical framework.

A Technical Dimension of Reflection

From the data, it was evident that teachers talked about statistical knowledge highlighting its instrumental and utilitarian function. In spite of statistics being a powerful tool to empirically study the world, this was not evident in the first sessions of the professional development program. The instrumental vision teachers had about statistics could be the result of teachers' experiences as students of statistics. Most of them were taught statistics privileging concepts and procedures. We discussed this hypothesis somewhere else (Zapata-Cardona & González Gómez, 2017). Teachers' fragments of their speech referring to statistics and statistics teaching from an instrumental utility point of view could reveal a technical dimension of teachers' reflections. These technical reflections took place mainly at the beginning of the professional development program. Teachers expressed the importance of statistics in terms of:

- Passing a test when they were students
- Training students for taking standardized test
- Preparing themselves in specific subjects in order to teach them properly to students

Teachers also expressed some reflections about the teaching of statistics mentioning aspects like:

- Privilege graphical representations and organization of information in tables and their respective interpretations
- Prepare the lesson by studying a topic from a textbook and then having a direct teaching of the topic
- Collect activities and exercises to have enough and diverse resources to teach statistics to students

The following excerpt illustrates teachers' discourse about statistics that suggest their vision of statistics as an assortment of concepts and procedures that reflects their technical vision of statistics and statistics teaching

> The majority of statistical questions in the university entrance examinations are based on tables and graphical representations. Consequently, I work that a lot with my students (Daniel' reflection).

A Practical Dimension of Reflection

As the professional development program progressed, the participant teachers were open to considering the statistics science as a tool for empirical inquiry. Participants discourse started to reveal some traces of statistics as a tool beyond preparing students for standardized tests. Teachers' speech started to consider the practical dimension of statistics. They mentioned statistics as a helpful subject for:

- Preparing students for their professional life
- Supporting the process of decision making
- Solving problem

To illustrate this practical dimension of reflection in the participants, we cite one of the teachers that brought an example in the context of decision-making:

> Somebody is selling me a theft insurance but my car is a Renault 9. I wonder whether those cars are being stolen? If I know those cars are not being stolen, do I really need that insurance? Then, statistics takes me to foresee no a hundred percent of the times but at least gives me lights to take better decisions (Elmer' reflection).

A Critical Dimension of Reflection

At the very end of the professional development program, teachers expressed some reflections about statistics and statistics teaching that were beyond a technical and a practical point of view. Most of these reflections took place at the final interviews. Teachers referred to statistics as a tool to:

- Question results of statistical processes
- Establish criteria for decision-making
- Have a better comprehension of the world

To illustrate the critical reflection dimension, we cite the intervention of one of the participants at the very end of the professional development program in his final interview. He highlighted statistics as a tool to understand the world.

> Teachers take [students] to a learning situation where students can understand a certain phenomenon. It is important we take statistics as a tool to solve, interpret or understand this world (Germán's reflection, final interview).

CONCLUSIONS

One of the conclusions of this study is the power of professional development programs in the transformation of the dimensions of reflections of the participants. As the data showed it, at the beginning of the study, teachers talked about statistics and statistics teaching refereeing exclusively to the technical functionality of it. However, as the program progressed, the participants started to show some traces of practical reflections about statistics. At the end of the program, teachers' reflections were not exclusively around the technical and practical aspects of statistics but also around the critical aspects of statistics. We consider that professional development programs where

reflection is the foundation of their methodologists have the power to question teachers' daily practice and promote the growth and development of teachers.

One of the limitations of this study is that we were not able to contrast teachers practice at the end of the professional development program. We only examined teachers' development and growth through their speech and reflections. A future study in teachers' professional development could include information from teachers' practice and students' performance at the end of the professional development program to contrast the results of this study.

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