A PHENOMENOLOGICAL STUDY OF TEACHERS' PROFESSIONAL LEARNING AND THEIR UNDERSTANDING OF MATHEMATICS-FOR-TEACHING

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Galileo Educational Network Association (GENA) provided professional development for three years to mathematics and science teachers at a school in Calgary, Alberta. By the end of this programme teachers were interviewed with the purpose of understanding their perception of what they learned in terms of mathematics-for-teaching. We describe the professional development programme and preliminary findings from the analysis of the interviews in this report. By understanding teachers' perceptions in this case, we expect to inform future professional development programmes aimed at improving teachers' knowledge of mathematics-for-teaching.

Galileo Educational Network Association (GENA) proveyó desarrollo profesional durante tres años a profesores de matemáticas y ciencia en una escuela en Calgary, Alberta. Al término del programa los profesores fueron entrevistados con el propósito de entender su percepción sobre su aprendizaje en términos de las matemáticas para enseñar. En este reporte describimos el programa de desarrollo profesional y resultados preliminares del análisis de la entrevistas. Al entender las percepciones de los profesores en este caso, esperamos guiar futuros programas de formación profesional orientados a mejorar el conocimiento de los profesores sobre matemáticas para enseñar.

INTRODUCTION

The mathematical knowledge that teachers at school level must know has being under debate for decades. Most recently, researchers have proposed that this knowledge must be specific for teaching mathematics, as opposed to the knowledge required for other professions. For instance, Stylianides and Ball (2008) claimed that "teachers need to understand and use mathematics in ways that are specific to the work of teaching that often differ from the ways in which mathematics is attuned to the needs of other workplaces" (p. 308). While some researchers have attempted to categorize this knowledge, others argue that mathematics-for-teaching "is an open disposition towards mathematics, which entails a willingness to harmonize the competing evolutionary tensions of mathematics and teaching as they arise in pedagogical contexts" (Davis & Renert, 2009, p. 37). In this sense, rather than being prescriptive of what teachers should know, many researchers have focus on what teacher know, and can know, learn, in different professional development programmes. This perspective situates the teacher as an enactive participant, rather than a simple consumer of knowledge. Following this perspective, we acknowledge the role of the teacher in creating, and contributing to the collective

2013. In Preciado Babb, A. P., Solares Rojas, A., Sandoval Cáceres, I. T., & Butto Zarzar, C. (Eds.). Proceedings of the First Meeting between the National Pedagogic University and the Faculty of Education of the University of Calgary, pp. 79-84. Calgary, Canada: Faculty of Education of the University of Calgary.

learning, in teacher professional development programmes. In this report we provide preliminary findings of a research aimed at understanding teachers' perceptions of their learning during a three-year professional development programme provided by Galileo Educational Network Association (GENA) to all mathematics teachers in one school in Calgary, Alberta. We specifically address the following question: How has participation in professional learning with GENA been implicated in teachers' (perceptions of their) deepening understanding of mathematics-for-teaching? By understanding teachers' perceptions in this case, we expect to inform future professional development programs aimed at improving teachers' knowledge of mathematics-for-teaching.

GENA'S PROFESSIONAL DEVELOPMENT PROGRAMME

Two GENA mentors worked with teachers at the school during a three-year period from 2009 through 2012. During the first year, the teachers expressed an interest in working as a team on proportional reasoning. The mentors, who are also authors of this report, brought in a number of tasks for teachers to engage with and, then, to use them with their students. Both teacher and student responses to the tasks were discussed in a session with all the participant teachers. In planning for the second year, the teachers expressed a need to work with material more directly relevant to their classrooms at a given time—rather than working as a large team on shared tasks. In an attempt to bring teachers together around a common theme within which such a diversity of interests might be considered, we, the mentors from GENA, noted two common interests: (1) moving beyond procedure-based mathematics, with a distinction between problem solving and mathematical reasoning; and (2) finding links between mathematics and science.

To help teachers move more deeply into these areas, they were encouraged to ask two key questions regarding the tasks they were developing (in most cases independently of GENA mentors) for their students: (1) How does a particular context inform the development of mathematics? (2) How can the mathematics developed within a particular context (whether it be rooted in science, pure math, or whatever) be generalized/refined/expanded to be more broadly applicable?

Initial discussion of these questions occurred during whole-team meetings during which teachers shared work they had developed and implemented independently from GENA support; later in the year, the two mentors worked with some teaching pairs to help develop the tasks that they later brought back for sharing with the whole math-science teaching team.

During the third year, GENA mentors continued to emphasize the distinction between problem solving and reasoning, attempting to further problematize the notion of good context as merely useful. We also noted a tendency to reduce mathematical work habits and discussion to neatness and organization and to polite sharing respectively. To address these points, a list of criteria for strong work in mathematics was developed—based on educators in mathematics such as Kilpatrick, Swafford, & Findell (2001) and Mason, Burton, and Stacey (1982). This list provided a common framework for discussion between the six grade levels taught at the school.

Strong Work in Mathematics
Inquiry

- Reasoning:
  - Develops mathematical conjectures;
  - Tests examples and counter-examples;
  - Tries to explain *why* observed patterns are true and under what conditions they hold
- Problem Solving:
  - Develops a plan, modifies it as needed, simplifies if possible;
  - Identifies sub-problems and relates them back to the main problem;
  - Considers strengths and weaknesses of various strategies and how strategies are related
- Modelling / Mathematizing:
  - Describes situations mathematically (i.e. "mathematizes" rather than applies a teacher-given tool);
  - Considers strengths / weaknesses of model (e.g. "Is weight ÷ track area an appropriate way to describe 'sinkability'?");
  - Generalizes models of individual situations to models that work in a variety of situations

Knowledge

- <u>Procedural Competence</u> (strategies): Uses established procedures appropriately and accurately; considers reasonableness of answers
- <u>Conceptual Understanding</u> (big ideas): Understands connections between various mathematical topics (e.g. connections between multiplication and division; linear relations and proportionality)

***Mathematical* Work Habits** (Productive Disposition)

- Considers alternative ideas
- Tolerates <u>ambiguity</u>
- <u>Willing to try</u> own ideas before seeking help

Figure 1 Framework for Strong Work in Mathematics. Repreoduced with permission of Galileo Educational Network Association.

With these ideas in mind, GENA mentors met with each grade-level teaching pair to work through a particular mathematical task. In some cases, mathematical tasks were suggested to teachers, whereas in some other cases teachers brought forward something of their own that they wanted to try. In either case, the mentors attempted to engage teachers in exploring mathematical potentials that might otherwise have gone unnoticed. Following this initial meeting, the teams introduced the tasks to their students. Each team gathered evidence of student learning (written work and / or video-taped discussion) to share with the other teams at a large-group meeting. During these meetings, the mentors used the "Strong Work in Mathematics" document as a guide for discussion, reflection, and consideration of next steps. We repeated this sequence three times (with three different tasks) over the course of the year.

METHOD

In order to understand teachers' perceptions of their own learning and deepening, we took a phenomenological research approach. More particularly, we took a phenomenological approach as described by Morton (1994). Teachers were interviewed by pairs according to the grade level they taught during the third year of the research. Table 1 describes the gender of the pairs of teacher, as well as the grade levels. Interviews were transcribed and revisited by the authors separately. Then, results were compared and discussed. The transcriptions were analysed using Nvivo software in an open initial coding.

Gender	Grade Level
F F	4 (Canada) – 4 elementary (Mexico)
M F	5 (Canada) – 5 elementary (Mexico)
F F	6 (Canada) – 6 elementary (Mexico)
M F	7 (Canada) – 1 secondary (Mexico)
M M	8 (Canada) – 2 secondary (Mexico)
M M	9 (Canada) – 3 secondary (Mexico)

Table 1: Interview pairs by gender and grade level.

RESULTS

For this preliminary analysis, we identified two main themes: (1) interaction with other professional development programmes, and (2) teachers' understanding of rich mathematical tasks. The interactions with other forms of professional development were evident in the interviews as teachers connected their work with the work done with GENA mentors. For instance, the Grade 4 teachers were very self-directed and actively looked for learning and communicating with other teachers online. When commenting about one of the problems suggested by GENA mentors, one of the teacher mentioned that similar problems were found in a website.

> Teacher G4: We actually found similarly structured problems called Lots of Lollies on the NRICH website so we submitted our students' solution to the candy problem [from GENA] to the NRICH website. … we ended up Skyping with one of their professors at Cambridge about what our kids have been doing in Math

Sharing students' work in this type of problems became another form of professional learning. One that was self-directed and allowed communication with other experts in education.

A new teacher who only participated in the programme for a short time by the end of the third year recognized the influence of GENA's programme on the way partner teacher and coaches modeled teaching, which as considered as another forms of professional development, as we can read in the following excerpt.

Teacher G7: I wasn't here when [the Framework for Strong Work in Mathematics] was developed … I wasn't really aware that it was Galileo.

I've been influenced by that …. I've seen model for me in with my new coachers or through my partner teacher

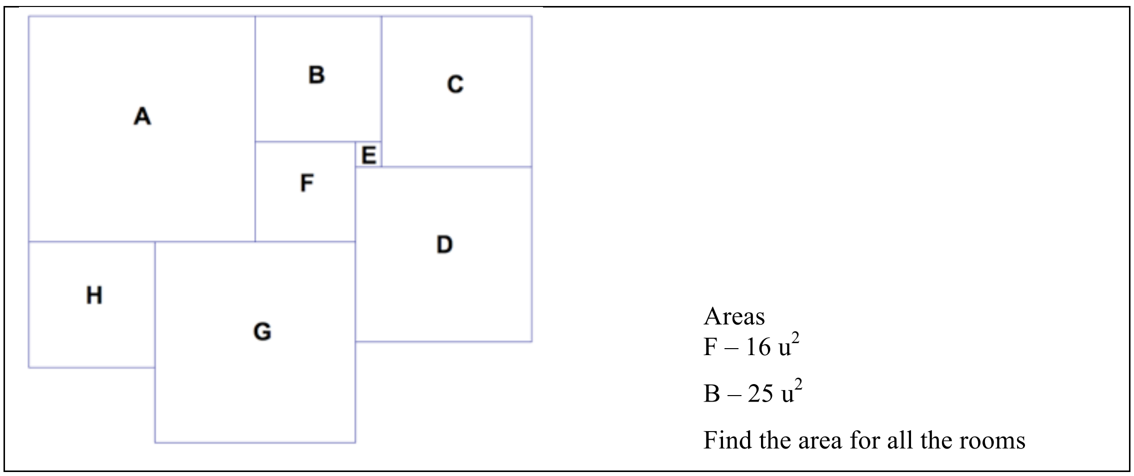

Figure 2 Museum Problem

Teachers' understanding of rich mathematical tasks included interrelated aspects such as: multiple entry point, diverse ways to solve math problems, communication in class, students developing procedures, and selecting/adapting mathematical tasks. The last aspect is particularly interesting as it represents a particular teacher's skill: adapting mathematical tasks to enrich mathematical thinking. We show and example here: the museum problem. This tasks was proposed by one of the teachers and GENA mentors modified it to include a stronger inquiry approach. The teachers recognized the value of the modified problem.

The original version provided the length of the sides and only asked for the perimeter and the area, which could be found by a direct calculation.

Teacher G6: So I think a lot of that has to do with the strong work in mathematical. … I think it was just how even recognizing some of the different concepts that come from a problem because that problem was basically just about area and perimeter but then it worked into things like the conjectures.

Recognizing and adapting mathematical problems was a recurrent topic in the interviews. One teacher mentioned a change in focus from direct procedure, or 'road map,' to tasks that foster conceptual understanding.

> Teacher G5: I think sometimes what makes up good Math problems is the way the teachers approach them. You could take a bad Math problem … if you remove some of the road maps, … and you ask them the conceptual question.

CONCLUSIONS

The interactions with other forms of professional development were varied and in some cases significant. The two examples provided here consisted of teacher self-directed learning, and the learning from the partner teacher and coaches. In the former case the interaction with GENA was in the 'structure' of the mathematical problems, while in the later the connection was through the Strong Work in Mathematics framework. Particularly, this framework impacted on teachers' decision in selecting and using mathematical tasks.

References

Ball, D. L. (1990). Prospective elementary and secondary teachers' understanding of division. *Journal for Research in Mathematics Education*, *21*(2), 132-144.

Davis, B. & Renert, (2009). Mathematics-for-teaching as shared dynamic participation. *For the Learning of Mathematics 29*(3), 37-43.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: National Academy Press.

Mason, J., Burton, L, & Stacey, K. (1982). *Thinking mathematically.* Toronto: Addison-Wesley.

Morton, F. (1994) Phenomenography. In T. Husén and T. N. Postlethwaite (Eds.) *The international encyclopaedia of education* (2nd ed.). Oxford: Pergamon.

Stylianides, A. J., & Ball, D. L. (2008). Understanding and describing mathematical knowledge for teaching: Knowledge about proof for engaging students in the activity of proving. *Journal of Mathematics Teacher Education*, 11, 307-332.