Two perspectives on diversity based on the pedagogical consultant's work on problem-solving in a teaching context

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Abstract

Our presentation addresses diversity, one of the themes of SEMT 2017, through the lens of the pedagogical consultant (PC) profession. This diversity is considered, on one hand, from the angle of the utilisation of in-class problem-solving and what it requires from teachers. On the other hand, we also look at it from the angle of PCs, these upstream actors that accompany teachers in the development of their practice in relation to problem-solving.

Keywords: Collaborative research; pedagogical consultant; problem solving; reflective practice; classroom context

Introduction

Problem-solving (PS) is a key issue of mathematics teaching throughout the world as evidenced by the important part it plays in curricula (see ZDM thematic issue, 2007). Many studies have contributed to informing this notion of problem, its characteristics in relation to different intentions, its potential, as well as the complexity of in-class problem management (Brousseau, 1983; Douady, 1987; Schoenfeld, 2007; Coppé and Houdement, 2009; Lajoie and Bednarz, 2012, 2014, 2015; Arsac *et al*., 1988; Charnay, 1992-93; Tanner and Jones, 1994; Grenier and Payan, 2003; Adjiage and Rauscher, 2013; Oval-Soto and Oliveira, 2012).

In this context, pedagogical consultants (PCs) are as key actors as they are called upon to assist teachers in situ in relation to in-class PS. A collaborative research project conducted with 8 PCs from different school boards and working with elementary level teachers has sought to better understand the more specific issues they face with regard to PS in a teaching context, and the ways to tackle them. In this presentation, we focus on issues regarding both the diversity faced by the teacher in a classroom teaching situation and the diversity characterising the PC's teacher assistance work. Before discussing some of the elements emerging from the analysis, we will come back to the role of these PCs and the reasons that lead us to investigate these issues.

1. The PC's role within the Quebec education system

PCs have been part of the Quebec education system for over 30 years. They work with teachers as "expert advisers" in pedagogy and intervention (Héon, 2004): they provide information, support and training to teachers. They also collaborate in implementing educational programs and policies, and are

therefore considered by school managers and teachers as "resources" for their implementation or for innovation development (Houle and Pratte, 2003). The PC is therefore one of the actors influencing the teachers' work and, by extension, what is being implemented by the latter with students in the classroom.

A number of studies on the PC profession mention the importance of developing a *professional credibility with teachers* (Little, 1985; Kent, 1985; Nunes, 2011), highlighting the *sensitive nature of the relation with ministerial authority* in this relationship (Draelants, 2007; Lessard, 2008;Duchesne, 2013). Between teachers who sometimes "resist" the institution's directives and an institutional agenda carried by the PCs, the relation to authority is a source of tensions (Duchesne, 2013), leading PCs to distance themselves from ministerial prescription, a distance they need to base their action with teachers (Lessard, 2008).

A *tensioned identity* appears crucial to understand the difficulty of working with teachers (Draelants, 2007): as they themselves come from the teaching profession, and generally recruited on the basis of their experience of innovative practices, PCs are, according to Draelants (2007), an "elite segment" of the teaching profession, while defining themselves as teachers serving other teachers. Thus, PCs seek to assert themselves by building on both dimensions of their identity, and seeking the right balance between the peer and the expert. This analysis, and others, underlines the complexity and subtlety of working with teachers and the *skills it requires*: use of a common language, use of relevant in-class situations, reciprocity with special attention given to teachers' knowledge and experience, without imposing what the work should be (Little, 1985; Nunes, 2011).

2. Exploration of problem-solving issues in a teaching context

The present collaborative research project (Desgagné, 1997; Bednarz, 2013) was organised around pedagogical consultants assigned with a mathematics task in elementary education as well as researchers in didactics of mathematics to explore the issues related to problem-solving in a teaching context. For PCs, this subject poses a real challenge as we have been able to observe in national meetings. The difficulties experienced by teachers in relation to the utilisation of problems in the classroom, and their evaluation, impacted on the requests they submitted to PCs, who were not always in a position to respond, or who had questions about them. Of course, PCs have developed ways to answer these requests, but they felt the need to distance themselves from these spontaneous practices, and to refine their understanding of the issues and questions in order to support their interventions.

Thus, the need to clarify what problem-solving entails in a teaching context, to identify the related issues and potential approaches, represented a significant challenge for PCs. Incidentally, their questioning concurred with our concerns as researchers. Indeed, we had developed an interest in these issues following an

historical analysis of Quebec's official documents from 1900 to this day, an analysis that allowed measuring the extent of this challenge: by highlighting the increasingly ambitious nature of the PS-related functions (Lajoie and Bednarz, 2012, 2015) and the almost nonexistent information provided to teachers to address problem-solving (Lajoie and Bednarz, 2014). These two considerations have confirmed the importance of furthering research by combining researchers' and PCs' knowledge and experience with a view to clarifying the issues being raised in relation to this subject. The following questions guided our investigation: What characterises the issues faced by pedagogical consultants in relation to problem-solving in a teaching context? What is their significance in the PCs' work context? What characterises the methods that were developed to take these issues into account? What insight can this provide us on their work, in return?

The analysis we present is part of this more comprehensive research project. It focuses on discussions that took place between PCs and researchers as part of the group's reflective sharing sessions. The participants were actively involved in various explorative and analytical tasks considered as a means to trigger discussion and clarification of questions and points of view.

3. A first aspect emerging from the analysis: Diversity related to the work of the PC who reflects upon PS in a teaching and teacher assistance context

In the period used for analysis purposes, the different participants − PCs and researchers − were grouped into teams of 3 or 4 persons. Each team addressed the "Giant's foot" problem (see statement below) without numerical data, and tried to find a) what it allowed to work on, b) how the problem could be worked out in class, and c) as PCs, how it would be possible for them to use it with teachers.

The discussed "Giant's foot" problem is presented in the form of a picture with the following text:

This picture was shot in an amusement park in England. It shows part of a giant's leg. What is the giant's height?[1]

In the plenary session that followed, the teams shared their exploration of the problem[2]:

R1: … I realise that we did not begin with "what it allowed to work on". We really got into it [thinking that] we would resolve it. […] we [in our team] all

[1]Rauscher Jean-Claude and Adjiage Robert. (2012). Espaces de travail et résolution d'un problème de modélisation. Proceedings of the symposium *Espace de Travail Mathématique 3*. Montréal, 24, 25, 26 October 2012.

[2]The pedagogical consultants are identified PC1, PC2, etc., and researchers are R1, R2, etc.

worked with the idea of ratios-proportions, but not the same objects were put in ratios and proportions. That was the difference.

This team's participants have all undertaken the reflection and exploration of the "Giant's foot" problem by *first positioning themselves as problem solvers*. Each one has resolved the problem on his own and the sharing of solutions brought them to identify the reasoning they used: some of them set a ratio between the length of the man's foot and the length of the giant's foot; this allowed them to consider the ratio of the man's height with that of the giant by keeping the same proportion. Others have rather set a ratio between the lengths of the man's foot over its height, and then considered the length of the giant's foot and his height in the same proportion.

Sharing the solutions brought up questions on concepts and processes used to resolve the problem. The participants then *considered the problem from a mathematical point of view*:

R1: We realised that we were in an estimation process, [and] a question quickly arose because our two processes produced a variance [in the answers obtained], so we said since we are in estimation, yes a variance is possible, but what is the significant variance that will tell us that our reasoning is inappropriate or that [the variance] can be acceptable.

PC3: the variance also lead us to go back and review the data we had used […] when we measure something, where do we start from, to what extent do we go, from what angle did you measure it […] also to see the incidence of our initial measuring yardstick, assuming we transfer it to obtain the giant's height, which is seven times our own, finally the small difference between the first unit we had, i.e. seven times, it creates a significant variance that we had to […] take into account.

On one hand, the discussion addressed the idea of the meaning of estimation, which entails a measure that presents a certain variance with an accurate measure. On the other hand, it also focused on different elements referring to the measuring process such as the end points and the point of view (perspective, angle) considered since the exercise was done from a picture, the selected yardstick and its impact on the result.

This idea of variance was also considered from the students' perspective, as a source of discussion with them to validate the reasoning and processes used. Thus, the participants adopted a *didactic point of view centered on learning and potential developments* provided by the problem:

PC5: […] you arrived at different numbers and then you questioned yourselves on this, right?

R1: Well, that difference did not bother us, we wondered to what extent /

PC5: we tolerate it

R1: The difference is acceptable. What tells us that our estimation was right? […] Perhaps we didn't use a proper reasoning or a good process because the difference is too big or something like that. We did ask ourselves questions about that […] we said "this might be an interesting discussion topic in class".

Another team said they addressed the problem in a similar way and noted a potential discussion topic with students. They also sought to see how such discussion could be conducted in class:

PC1: We had a similar discussion on what do we do with a student or a group of students who would address the problem from a wrong angle, you know, they see it as additive: the height is that much more than […] rather than that many times more than. Then we came out with the idea that we could present all the different answers and have the group explain what is acceptable and what is not. It somehow goes back to the discussion you had on accuracy.

When the participants dwelled on the utilisation of the problem with students, they adopted a new perspective which is that of *the teacher in class*. For the participants, steering the resolution of a problem with a group of students is fairly complex:

PC3: we pursued our reflection this way… Now, one of the difficulties is planning, but R3 said "it's also the capacity to propose problems in the context and on the spot", but we noted that it took fairly high aptitudes to manage this type of situation, to catch the ball on the fly with an answer that would be wrong, […] to question the students in order to readjust their reasoning or to see where they made the error, and not going in all directions, and then [as teachers] being taken by surprise.

PC3: R1 [talked about] the variance between our two answers [and] we asked "how to explain this variance?" […] Ok, we took the length of the man's foot over the length of the "giant's foot", and at the same time PC4 was writing the mathematical equation that […] illustrated […] how to solve the problem using the two different ways, but I'm not sure that all teachers would have the skill to do this, to go over a student's reasoning, formulate it in a mathematical equation form, to isolate a variable, and then say "Ah! This is what explains the error!"

The participants' reflection on the problem at hand then changed its focus. The discussions shifted towards the perspective of *assisting teachers with the challenges posed by PS* in a teaching context. The "Giant's foot problem" was then approached in terms of what it allows to develop in teachers:

R1: … when we clarified our position "Ok, we are PCs and we want to work that out with teachers", PC4 said […] "I would proceed to bring teachers to accept fuzziness management" […] there was that idea to use this type of problem with teachers to bring them to develop the capacity to manage fuzzes […] we found that idea of fuzziness management interesting.

Finally, other PCs mentioned the discomfort felt by teachers towards the utilisation of such problems without numerical data in class. Indeed, they consider them quite different from the problems usually worked on, and which are found in the teaching material and also used in provincial evaluations. Anticipating from the outset the teachers' reluctance, these PCs will propose to add a numerical datum to the "Giant's foot" problem (e.g.: the measurement of the fence height) in order to provide a more familiar point of entry into the problem. The preferred perspective is then that of the *problem designer*: the focus is on the problem as it is designed, on its characteristics and the possibilities to modify it, to change it with a view to making it more "sellable" to teachers, for instance.

Findings from this analysis: In the course of his practice, the PC conducts his/her reflection by adopting several different points of entry or perspectives on a problem: problem-solver, teacher, pedagogical consultant, problem designer, mathematical and didactical points of view. His/her activity is thus organised in an initial movement of deployment around a diversity of perspectives on a same mathematical problem. It is characterised by a second movement of tensioning, of negotiation between the different issues emerging from these entry points. For example, a potential discussion with students and the complexity of its management by the teacher; or between a problem that is difficult for teachers to manage and the potential of such problem in the assistance work with teachers. This clearly highlights the complexity of the PC's work due to the diverse perspectives to be used and coordinated as well as to their interwoven and dynamic nature.

To be able to do this, PCs tap into three types of knowledge (Lessard, 2008). First we have "*field knowledge*", which notably from their experience as teachers, but also from in situ observations. We see this for example when they refer to the difficulty for the teacher to manage this discussion, or to react to an error, or again the discomfort felt towards such a problem that has no numerical data, a problem that they do not know exactly how to resolve in class. Field experience provides a set of practical data that they must consider, what Lessard (2008) calls "field intelligence"; Second, comes the (2) "*theoretical knowledge*" underlying their interventions and argumentations (highlighted reasoning processes, concepts and processes at play, analysis in terms of the data they rely on and that may explain the variance, etc.); Finally, we have (3) *"counselling knowledge*", which can be relational and/or adult training knowledge (for example, in the way they consider modifying the problem to involve teachers in the situation).

4. A second aspect emerging from the analysis: diversity related to the utilisation of the problem in class

As discussed above, utilising PS in a mathematics teaching context represents a significant challenge for teachers at the planning stage, but also and more

importantly when it comes to manage problem-solving with students. R2 asked: "Are teachers interested in doing problem-solving or are they not?" PCs mentioned that the management complexity required for PS in class makes teachers reluctant to utilise problems with their students. As PC3 said above, "We noted that it took fairly high aptitudes to manage this type of situation". The studies conducted in Quebec on PS in a teaching context confirm the difficulties posed by PS management in class: about managing the validation process (Barry, 2009; Saboya, 2010), taking solutions into account (Oliveira, 2008), including erroneous ones, implementing a research culture (Barry, 2009) and using mathematical complex problems (Maheux, 2007).

In the analysed episode, still regarding the "Giant's foot" problem, a PC/researcher team noted that this type of activity lead with students required from teachers what they call "fuzziness management":

R1: And then we said, there are two potential fuzzes. One concerning … We're not faced with an estimation problem [explicitly, but] but we can work it out in that sense. So we will get different answers and this leads to good discussions as we just mentioned. So there is this fuzziness in terms of … of answers, but also fuzziness in terms of different entry points to the problem, different strategies and so we said "both aren't easy to manage". You need to be comfortable with that, you have to be able to tackle that.

Thus, part of the complexity of this type of management is due to the fact that the diversity of the students' answers to the problem can be related to the estimation process. And also to the diversity of entry points to the problem and the strategies used by the students, for example. There is also a diversity of mathematical notions that can be utilised, whether they are identified from the outset or emerge during the problem-solving process, or during the discussion with the students.

Therefore, this "fuzziness management" appears as an important in-class PS issue for PCs with regard to the question of diversity: taking into account the diversity of answers, strategies, different entry points to the problem to further student's learning, to accept uncertainty in the discussion and what may emerge from it. "Fuzziness management" represents part of the complexity of the teacher's work in class and will therefore become for the PC a matter of teacher assistance. An issue all the more important because the official Quebec documents give teachers very limited, not to say almost nonexistent information to address this type of problem-solving (Lajoie and Bednarz, 2012, 2014, 2015). These analyses of the PC's work and the official documents underline the importance of furthering research by sharing researchers and practitioners' perspectives to clarify and take into account the issues raised by the utilisation of PS in a teaching context, and those related to the teacher assistance provided by PCs.

5. Conclusion

Diversity as it is seen here through the lens of the pedagogical consultant's explorations around problem-solving puts into light adopting various points of view when thinking about people involved in one's work. Although this might be tempting, we think these perspectives cannot be simply reduced to that of a student, a teacher, a mathematician or a researcher for example. Students and teachers can both be, at time, problem solvers, problem composers, and even in some way share the pedagogical and the didactical configuration of the classroom (e.g. Roth and Radford , 2011). Navigating the fuzziness of thinking about classroom problem-solving in a PC context also highlight the potentially conflicting nature of these perspectives: something the image of different roles or positions does not necessarily captures best. To further our joint inquiries into the issues faced by pedagogical consultants in relation to problem-solving in a teaching context, one way to think about this diversity we would like to explore in the future draws on Mikhaïl Bakhtin's (1993) notion of polyphony. For Bakhtin, attenting to the diversity found in the multivoicedness of speech and thought is fundamental to understanding people's actual lifes and experiences. His work mostly focuses on how utterances create *signification* (as opposed to "meaning") by responding to and being responded to by other utterances. While explaining this, Mayen (1999) also refers to Bakhtin's notion of polyphony as a "potential vector of development" (p.75). In the context of a collaborative research such as ours, we thus readily envision two ways in which polyphony could be a powerful concept to explore: 1) to examine how different voices populate (and even *saturate*) PC's work around PS; and 2) to observe how the research context itself allowed these voices to be heard, respond to one another, and thus contribute to the collaborative saturation of signification around PS. This might offer a powerful way to deepen our conceptualisation of the complexity of PC's work, and support it.

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