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► To cite this version:

Caroline Lajoie, Lily Bacon, Nadine Bednarz, Jean-François Maheux, Mireille Saboya, et al.. How to choose problems? A co-construction between researchers and pedagogical counsellors. Thirteenth Congress of the European Society for Research in Mathematics Education (CERME13), Alfréd Rényi Institute of Mathematics; Eötvös Loránd University of Budapest, Jul 2023, Budapest, Hungary. hal-04414723

HAL Id: hal-04414723

<https://hal.science/hal-04414723>

Submitted on 24 Jan 2024

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How to choose problems? A co-construction between researchers and pedagogical counsellors

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We present results stemming from a collaborative research (CR) project, bringing together researchers in didactics of mathematics and pedagogical counsellors (PCs) in mathematics at the primary level. This research was intended to clarify issues facing PCs around problem solving in the teaching context, and the support of teachers. One of our goals was to enlighten approaches to take these into account and, in turn, to clarify the profession of PC. In this study, our analysis is based on that which they developed together during their examination and discussions of various mathematical problems. To that end, we draw upon a theoretical perspective, polyphony and dialogism borrowed from Bakhtin, as well as Fabre's concept of problematization. The analysis reveals a web of meanings from a variety of voices emerging during the sessions with the PCs, which in return feeds the collective view of a complex and multidimensional professional field.

Keywords: Collaborative research, problem solving, pedagogical counsellors, supporting teachers.

Introduction

The reflective activity in collaborative research (Bednarz, 2013) allows for the intersection of experiences, points of view and understandings around a common object. In this study, we report on a project developed around the work of a group of researchers and pedagogical counsellors (PCs)¹ on problem solving in the classroom, and teacher support. One concern that came about is the choice of problems. What is good about this or that problem? For whom? Why? Do teachers actually *choose* problems? In this paper, we examine the collaborative work of researchers and PCs around such questions and show how they call upon different perspectives while constructing an understanding of “choosing problems” and how to support teachers in doing so.

Problem solving is a central element in teaching mathematics in Quebec and supporting teachers to do it in their classrooms a common concern of researchers and PCs. Problem solving in the classroom poses challenges for both students and teachers, and PCs feel a need for finding ways to support teachers. Indeed, while functions associated with problem solving are increasingly ambitious (Lajoie & Bednarz, 2016), the guidelines offered to teachers are almost non-existent (e.g., Lessard et al.,

¹ In Québec, PCs work with teachers as “expert advisers” in pedagogy and intervention: they provide information, support and training to teachers. They also collaborate in implementing educational programs and policies” and they are considered as “resources” for innovation development.

2020). This, on the other hand, also explains why currently researchers are interested in understanding the professional activity behind problem solving in the classroom, and how teachers can be supported by PCs, whose work also needs to be documented and conceptualized (e.g., Hanin et al., 2021; Lajoie et al., 2022; Lessard, 2008).

Methods

A collaborative research project took place from 2015 to 2018 with the goal of better understanding problem solving in the classroom, teacher support, and PCs in mathematics' profession. Five researchers (the authors) and 8 PCs participated in the project, which consisted in a total of 17 one-day sharing sessions. The discussions that took place during those sessions touched on various aspects of problem solving and supporting teachers, among which the choice of problems on which we focus on in this text. Specific problems were often examined and discussed, including "The giant's foot" (Figure 1). This problem was contributed by a researcher fulfilling the assignment (decided by the group) to bring a problem without numerical data (PWND).

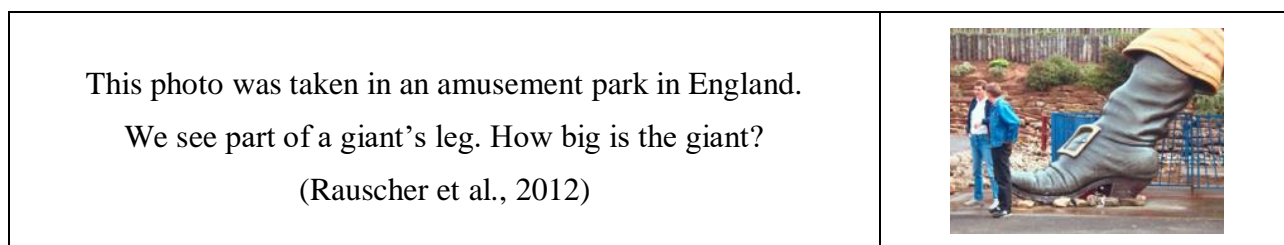


Figure 1: Two PWND discussed by the group

Researchers and PCs discussed these problems to try and see why teachers might choose them or not, why they should be better appreciated by the teachers, and how to make them more appealing.

Theoretical background

To understand how researchers and PCs addressed these questions, we identified all the episodes in which the question of choosing problems arises and analysed them through the concepts of *problematization* (Fabre, 2006) and *polyphony* (Bakhtin, 2010). For Fabre (2006), problematizing involves examining different components of a phenomenon to identify that which can be problematic: a non-linear process similar to an investigation which progresses through an "accumulation [of] references generating inferences and new references subsequently, a dialectic of indices and proofs" (p. 20). One aspect of this process is the identification of the phenomenon, of something which "questions". A second is the construction of the problem, a more "in depth" examination of what questions. A third is the resolution, in which judgements and courses of action are drawn. Bakhtin developed the concepts of polyphony and dialogism to represent actual everyday languaging (Bakhtin, 2010). He explains how a multiplicity of voices co-exist and express themselves when people speak: they are connected dialogically to each other even within the discourse of a single actor, even in a single utterance². This inspired us to approach the interactions between researchers and PCs looking at how they convoke different perspectives and brought us to the following research question:

² For another look at polyphony, please refer to Bednarz et al. (2020).

how can the concepts of problematization and polyphony be used to characterize the co-construction by PCs and researchers on the topic of choosing problems for the classroom?

Analysis: What is co-constructed in the researchers - PCs interactions

A certain way of defining “what questions”

An initial transversal glance at the verbatims reveals that the actors' questions regarding the choice of problems in the teaching context or that of support (which Fabre terms the position of the problem) develops over time. With changing lenses, choosing problems is questioned at various points in time during the same meeting, and picked up again from one session to another. Again and again, it is re-examined, questioned in a different way, even at a time when this is not really expected. The analysis reveals an open investigative process, in which the actors do not simply and immediately seek to decide, to reach a conclusion (with advice, for example, which would specify how to choose a problem, on what basis, and with what underlying rationale, or to offer paths to take in this direction). The phenomenon investigated seems too complex for that. And while the actors attempt to settle on some aspect at a given point in time, it is only on a temporary basis that they do so. Through this, they provide themselves the means to structure the collective thinking which is developing (Maheux et al., forthcoming), a structure that is subsequently revisited once again as the discussions continue.

Such an open investigative process may be retraced in the analysis, for example, of a meeting in the first year (verbatim of February 22, 2016). The question of choosing problems comes up at various moments in the session, emerging from discussions around PWND suggested by researchers and PCs, including those in Figure 1. Different questions arise and are modified. What PWND can one find? How can one create such problems, given the difficulty to find any? Can we always transform a problem into a PWND? Are PWND always of the same type? What purpose do they serve? For the students? For the teacher? For PCs and teacher support? What is their potential? How complex are they? etc. The choice of problems is also recursively interrogated through this and re-visited later on in connection with other broader questions. What is the interest of these problems? Do the teachers ask why they are worth using? What aspect of problem solving do they connect to? And so on.

A particular manner of entering a process of problematization emerges from our analysis. Each actor seems to find himself or herself wanting to repeatedly endorse the question, making it their own, bringing it back for further investigation in the light of something in the ongoing conversation she feels is important, relevant, etc. This way of circle the question (rather than, for example, clearly defining or delineating it) is central to understanding the meanings which emerge from the problematization. Choosing problems is indeed constructed as something open to various possibilities, something to make explicit with teachers and to develop, and something teachers will also have to refine by themselves (for example in relation with what they observe in their own struggle and success while doing problem solving in the classroom). But then again, what did the participants had to say about problem solving and teacher support, how did this examination unfold, what are these various perspectives actor took on the issue?

In-depth examination of “what questions”: the mobilization of many voices

Our analysis reveals an in-depth examination of “what questions” (Fabre’s conditions and data of the problem), soliciting multiple voices. No less than 10 different voices can be heard: that of the *problem designer*, of the *problem solver*, of the *analyst*, of *research* (empirical, theoretical), of the *student* (generic, fictional, real), of the *classroom* (real, possible, or ideal), of the *teacher* (generic, real), of the *PC*, of the *university teacher-trainer*, of the *institutional stakeholder* (such as program designers and school administrative). Researcher and CPs both make themselves analysts, problem solvers, designers and so on, convoking these voices based on their experience for example with students, teachers, other researchers, or trainers. We will return to this with two examples illustrating voices invoked by the actors. An analysis of different voices effected on just a part of a verbatim (February 2016), offers an overview of this entanglement of voices (see Figure 2).

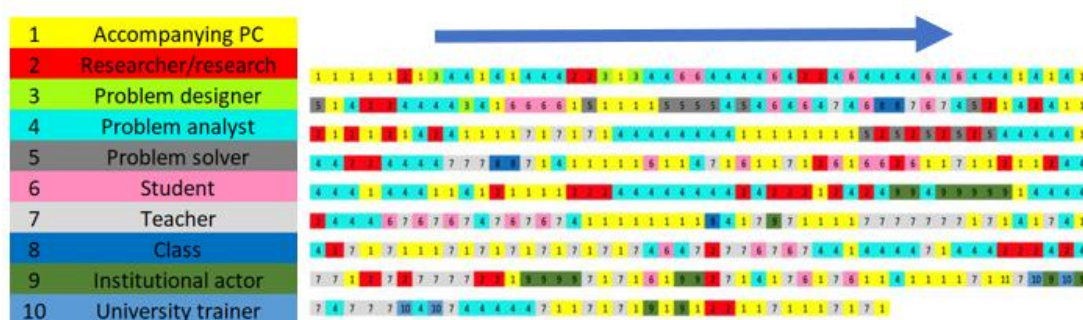


Figure 2: Analysis of a part of verbatim (example from the session of February 2016)

On the one hand, conversation sometimes takes the form of “monologues” co-produced by a few people. In the example below, the same voice, that of the analyst (in cyan, referring to the code in Figure 2), is in turn invoked by 3 PCs and a researcher while discussing different kinds of PWND:

PC1:	[speaking of transforming a problem in a PWND] But it needs to be reformulated.
R1:	Yes, we could transform any problem into a problem without numerical data, but it would have to be reformulated; it would have to be rethought.
PC6:	I realize here... sometimes problems without numerical data make student think without numbers, but some problems have spaces where the student are to insert numbers. There are books in a library, imagine x books, and also there are x shelves. How many books will there be on each shelf? A problem like this can show whether the child is reasoning “there are an equal number of books on each shelf” [...]
PC1:	Also, a similar idea with open problems [where] students can] add data...
PC5:	Listen, it’s interesting; we’re already in the process of discussing differences ...

Figure 3: A ‘monologue’ co-produced by 4 people

On the other hand, a succession of voices may appear in a singular actor utterance. Something like a dialogue where the person takes on several roles, convokes different voices, and makes them interact with each other. Here is an example involving R3. The colours refer to the code in Figure 2.

R3:	When we were saying “these are problems that allow us to work more with meaning, relationships” ... not necessarily. The student comes in saying “well, I’ve got a problem; I have to find a solution.” So, he’ll find me a bit funny when I give him a problem without numerical data and he’ll get some [numbers] himself. Therefore, working on the meaning, I don’t know if he’ll do that so much. This shows that,
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with this type of problem as well as with those with numerical data, the role of the teacher is essential: it is central. What should I stress? What type of questioning will I have? What will I seize upon? So, as the teacher, one has to ask “what will allow me to make the link with that aspect there of meaning?”

Figure 4: A ‘dialogue’ produced by a single person

With such analysis, we see multiple perspectives convoked in the examination of how to choose problems. But a more detailed analysis of the dialogical rapport amongst these multiple voices is vital to understanding the meanings which develop in this problematization.

Elements emerging from the dialogical rapport amongst various voices

We will illustrate the network of meanings which emerge from 2 examples. The first one shows how the voice of *the teacher* is brought about to issues in relation with choosing problem and supporting teachers in the light of some conditions they must deal with. The second exemplifies how the voice of *the PC* is set in dialogue with that of *the designer* and *the analyst* in relation to supporting teachers.

Example 1: Calling on the voice of the teacher

In the following extract, the voice of the teacher is made heard in a discussion on “The giant’s foot” problem (see Figure 1). While researchers and PCs seem to agree on the problem’s potential for the classroom, one participant plays the killjoy. Becoming the devil’s advocate, PC7 lets the voice of a fictional teacher being heard, raising counter arguments to the highlighted potential of the problem:

PC7: But beyond this ... in terms of complexity ... what we also discussed is that ... here we’re returning to the idea of benefits. If I imagine myself as a teacher, if one wants to openly experience the exercise, precisely in not directing it... well in my head I agree to spend 75 minutes on it, without knowing precisely what I will get out of it ... I get something from it ...we will have experienced a mathematical exercise ... but am I able to check off some elements of my program? Well, that depends on what comes out of this because we have had this discussion when we said “okay, let us admit that we are removing the question,” since there I was acting a bit like Dan Meyer. You’re showing the image, then you ask, “what questions can we ask about this?” [...] This can move off in all directions; then if you agree to play the game, that is good, one looks at the image, what question it triggers, one tries to respond to that and then, when you are fully experiencing this, at the end am I certain that we will have [fulfilled the program requirements]?

In this extract, PC7 makes the voice of the teacher talk about the classroom and its constraints. Through this voice, PC7 raises the question of *time*, which would not allow the teacher to propose a problem likely to make the class “take off in all directions,” and the question of the *program*, with which the problem of the giant’s foot might not be seen (by the teachers) to be consistent.

Here, the teacher’s voice enters into a dialogical rapport with all that which was developed previously in the group. Coming to relativize what had been put forward to this point with respect to the potential of the problem of the giant’s foot (and, in the background, the idea of having teachers choose such problem), the teacher’s voice highlights a split between, on one hand, the potential perceived by PCs and researchers, and, on the other hand, the reservations which the teachers could have with respect to this problem due to his/her context. Consequently, while researchers and PCs stress the fact that this problem is great in many ways (open, rich/complex, etc.), the teacher’s voice draws attention to

the fact that it could be perceived, on the ground, as excessively open, and too risky. It could go off in all directions, take too long to solve, lack clear connections to the program, and so on. That is, the question of choosing problem gains another layer, the issue is complexified, and so this issue of supporting teachers which how these new dimensions also need to be addressed.

Example 2: Dialogue with the voice of the PC

In the following extracts, the participants are still discussing the problem of the giant (Figure 1). After resolving the problem and having discussed the potential of this problem for the students, researchers and PCs manage to categorize it as a good problem. Nonetheless, the PCs anticipate that teachers would express reservations about imposing this on their students since it is difficult to facilitate because it leads to a variety of resolutions, thus convoking the teachers' voice. Then, PC6 proposes "selling points" for this problem: seeking elements in the program which justify using it (such as estimation), inserting it in a class routine, insisting on how it avoids reading difficulties (as opposed to long "word problems") and that it allows students to have discussions:

PC6: As a PC, this comes to highlight... what are the selling points of the task ... that's what we were trying to feature, going through some elements of the program such as estimation, everything involving measurement, ... and without the obstacle of reading ... it is in fact, trying to present the problem so that teacher adheres to [this type of problem], ... if we find that [type of problem] interesting, [we] have to find some arguments because some people could be recalcitrant.

Subsequently, one researcher calls on the designer's voice to remind the group of another "selling point" proposed earlier by a PC which had not been discussed so far: adding a numerical value to the problem. But PC5, invoking the voice of the analyst, stresses that this would transform the problem:

R3: The suggestion of PC4 to add a ... number, it was from this perspective of saying "oh well, I have teachers who perhaps would be hesitant to use that with their students, but in adding this...". Then one was saying "this will be in accordance with PC6's comment "that as PCs, yes, we try to push the teachers a little but, at the same time, we have to cater to their needs, contexts, and constraints."

PC5: But we've got to be aware that if we do that [add a value] we risk doing (inaudible). One of the negative consequences is ... stopping [the reflection].

Through these extracts we see diverse voices come together, react to one another and resonate. We have the teacher's voice in a dialogical rapport with that of the analyst through the explanation of selling points. Then the voice of the designer also enters in a dialogue with the voice the teacher and the analyst underscoring a tension between the desire to meet with the teachers needs and that of maintaining the potential of the problem. Moreover, the voice of the PC in turn dialogues with that of the analyst, arguing that the real issue is countering teachers' use of a "general strategy"³ for problem solving, against which such a problem (the giant's foot) could prove to be fruitful. In the background, it appears that while getting teacher to appreciate the value of problems different than those they are used to is a key point in the question of choosing problems, is also at stake the way in which teachers do problem solving in class when insisting on "general strategies" is a problem.

³ This is the topic of other discussion we cannot include here. It refers to the idea of having students systematically follow a four steps model (understand the problem, form a plan, action the plan, look back at the solution), perceived as too rigid.

Conclusion

Our analyses reveal how researchers and PCs, in the context of a collaborative research, examine together various components of a phenomenon (choice of problems and supporting teachers) to identify what might prove problematic. Borrowing from Bakhtin's concepts of polyphony and dialogism and Fabre's problematizing allows us to grasp, if only partially, the intricacy of this problematization. Various perspectives, sometimes contradictory, emerge in the interactions of researchers and PCs, each in their own way feeding the examination of the issue. Through the problematization, a multiplicity of voices coexists, all speaking up to unpack the complexity of choosing problems for the classroom and supporting teachers to do so. We realize that PCs navigate this very complexity daily, and those voices help ensure the viability of what is being constructed, so PCs can adapt to the various realities they face when working with teachers. Researchers contribute to make those voices heard with their own insights on students, problems and so on.

The extracts presented here illustrate the meanings developed between researchers and PCs, and how they use this multiplicity of voices in dialogue during the sessions. We get a glance at how they progressively build an understanding of choosing problems as something to be worked on with teachers, something for which teachers need to be instrumented as opposed to, for example, providing them with so-called good problems. But doing so implies considering a network of perspectives, and this is a challenge for the PCs who want to support teachers to be able to respond to various constraints, especially if addressing the choice of problem with them conduct to complexifying the issue. This agrees with our past analyses showing that those PCs are concerned with actual teachers' receptivity to what is constructed with the researchers (see Hanin et al., 2021). Calling on voices which may play a large part in those teachers' practices promises PCs they can offer them something (e.g., about choosing problems) that is viable for the everyday classroom. But PCs do not limit themselves to report and work with what teachers or students express. In collaboration with researchers, they seek for additional input, and new ways to understand, articulate and respond to these multiple voices. The next stage for us is to examine if we can characterize what each of those voices brings to the co-construction: a study is in progress. But further research should also investigate how a given voice is progressively shaped through the collaboration.

Finally, we opened this paper mentioning how the reflective activity in collaborative research happens at the intersection of various participants experiences, points of view and understandings of a common object. Our analysis shows that while addressing an issue, the participants not only communicate from the perspective they would objectively be associated with (e.g., as a researcher, a PC, a teacher, etc.). They also actively and critically call on other voices to enrich their co-construction. While such feature might not be present from the get-go or in all collaboration attempts, they seem to us powerful markers of reflective activity, which also contributes to the quality of what is being elaborated. Further studies along these lines would also be welcomed.

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