

Collaborative research and professional development of teachers in mathematics

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Preliminary remarks

This conference is first and foremost intended to adopt a perspective on the advances in the field of mathematics education that stem from a new line of research that emerged in the 1980s and that brought together university researchers and teacher practitioners around questions related to practice in the classroom. In this presentation, I will attempt to clarify the conceptual bases of this collaborative research approach in order to better identify the theoretical and methodological issues at stake and to highlight its contributions to both the production of new knowledge in mathematical education and the professional development of the teachers involved in this research.

This reflection is based on nearly 15 years of research efforts conducted in collaboration with grade school and high school teachers. Collaborative research - and with this, our interest in such projects - began in 1989-1990, when I was Director of CIRADE (the interdisciplinary learning and development research centre attached to the Université du Québec à Montréal), a time that coincided with the establishment of research schools associated with CIRADE. The research school project involved a group made up of several teachers, the school administration, parents and CIRADE researchers, and was designed to gradually put in place, in the school, a research community focused on the joint development of interventions in various areas, based on the knowledge and reasoning of children and with the objective to improve this knowledge. The intervention design process sought to turn to good account the knowledge of both parties (classroom teaching knowledge developed, for example, by educational researchers; previously conducted research - in this area, researchers could draw on a wealth of knowledge; and the experience-derived knowledge of the teachers);

In these schools, different projects were specifically set up around: problem-solving in mathematics among young children; the learning of specific concepts (numbers, place value, operations, measures, geometry, fractions, etc.); constructing a meaning for mathematics symbolism; and the use of play in teaching mathematics;

The research continued with teachers from other primary and secondary schools in underprivileged communities around the development of interventions in mathematics teaching designed to: prompt children to construct a meaning for concepts (e.g., work with rational numbers, decimals, development of relational arithmetic, transition to algebra, etc.), develop certain mathematical competencies, and promote a different relationship to mathematics.

The research in these various social environments led me, in my capacity as researcher, to continually question the learning situations thus created. This compelled a process of adaptation and perspective-taking that revealed the need to take the context into consideration.

This process brought out certain key concepts to which I will return later: the centrality of confronting the context (the response to problems that arise cannot be universal); the plausibility of the situations developed, which must necessarily prove their effectiveness in context and which are constructed, restructured and enriched in

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context; and an adapted (i.e., practice-related) teaching know-how (which also necessarily entails moving away from a technician perspective). In conjunction with this multi-year research, the researchers involved in the various areas of these research efforts gradually felt the need to share their experience of collaboration in order to bring out the common elements and the particular aspects likely to clarify and refine the approaches all participants would subsequently adapt. This post hoc reflection on the procedures of inquiry implemented in the various projects (with respect to the collaborative research process adopted) led them to clarify, on the one hand, the theoretical and methodological foundations and to sketch out, aside from the various procedures, settings and approaches involved, a model of a shared collaborative research process. So doing, they gave voice to a concern with conceptualization in order to better understand this process, its contribution to research into education, and its consequences for practice.

So the reflection that I am inviting you to take part in is based on more than 10 years of experience in collaborative research and takes as its starting point a rather meta, retrospective view of the various projects carried out.

I will first situate the origin of this research (the reasons that led me as educational researcher in mathematics to become involved in a collaborative research process), which will naturally flow into a description of its foundations: a certain position taken with respect to practice.

I will then take up one example that I will elaborate in greater depth, bringing out its outcomes for practice and contribution to research into mathematics education.

The collaborative research model (conceptualization of the collaborative research process) growing out of these various research efforts will then be explicated, and I will end my presentation by showing the contribution that these research projects have made to the professional development of the teachers involved.

Origin of the collaborative research: Why engage in collaborative research in mathematics education?

The concept of collaborative research took shape around the idea of conducting research “with” teachers rather than “on” teachers. This simple formulation says much about the concept itself and what justifies its appearance in the world of research into education. A proposal to renew the relationship established between researcher and practitioner with respect to research related to teaching practice is implicit here (I will return to this aspect later). It follows that collaborative research takes place within a host of research practices involving the participation of teachers (one need only think of the action research movement and of the teacher-researcher, quite present in the mathematics teaching community). What specific characteristics distinguish research that has adopted this collaborative process?

For the purposes of clarification, it is a good idea to briefly consider the idea of research collaboration through the brief history of it that Catelli (1995) wrote in connection with the American educational context. This history brings out two perspectives from which the pertinence of collaborative research in education generally is justified:

The first perspective emphasizes the professional development of teachers within the framework of the school-wide team. In this instance, the justification of collaborative research rests much more on considerations of professional development. The idea of collaboration is associated with joint efforts undertaken among teachers, in

a spirit of reflexive community, and with its impact on practice conducted among students and on the institutional climate (Little, 82, 84, 90).

The idea of collaborative research and of a necessary collaboration between researchers and teachers also originates in the recognition of a separation between the world of professional practice and that of research intended to clarify it. By emphasizing the rapprochement required between university researchers and teachers, the justification of collaborative research rests more on considerations of research and the critique of such research. This problem exists only to the degree that it is considered necessary to establish a close relationship between research and practice - a challenge, in my opinion, of particular import to academics whose mission is to educate teachers (as in my case). To speak of collaboration between researchers and practitioners is to engage the issue of the relationship between research, which occurs in one particular area (in my case, mathematics education), and professional practice - i.e., the practice of teachers who teach mathematics. It is, in other words, to enter into the reciprocal enlightenment that each is able to provide to the other (Schön, 83, 87; St-Arnaud, 94; Curry, Wergin et al., 93)

When the very evolution of the concept of collaborative research is recapitulated, professional development and research appear at its foundations. These two aspects appear to be vital, all the more as they are also going to be found, as we will see next, at the base of our collaborative model.

Why this move into collaborative research in mathematical education more specifically?

The primary subject of my reflection, particularly in the framework of the various projects that were conducted with teachers, centres on the development of teaching situations aiming at significant mathematics learning on the part of students, worked out in relation to their ideas and reasoning processes and intended to make these more complex. Why, from this perspective, did collaboration with teachers at the level of research seem necessary to me?

It would have been possible to work on developing classroom interventions with the objective of achieving conceptual construction by the child, on the basis of a certain number of previous analyses (e.g., conceptual and epistemological analysis; the ways in which a certain concept is usually addressed in teaching, knowledge of children's reasoning, errors, conceptions, etc.). Much mathematics education research proceeds in this fashion, particularly those developed within the framework of the "ingénierie didactique" which is one of the serious contributions of research into mathematics education, conducted in France, for example. Within the framework of such "ingénieries didactiques", educational research contributed to developing teaching sequences that could be considered as possible sources of inspiration for teachers (take, for example, the work of Brousseau on rationals and decimals, Douady and Perrin-Glorian on surface areas, etc). However, the question of the reproducibility of these experimental situations in the classroom poses numerous problems. They occasionally undergo transformations - a natural outcome, to be sure, but one whose results are often greatly at odds with the researchers' intent. Teachers adapt a sequence to their way of doing things and, with a view to preserve the initiative as to classroom activity, end up modifying the initial project so much as to distort it in the eyes of the researchers. The same problems are encountered in the process of developing new teaching methods that focus on a particular subject (e.g., curricular developments) just as soon as a project initially developed by researchers (based on a number of previous analyses) is transferred to voluntary teachers (i.e., as part of a top-down approach that is encountered in the design of classroom materials).



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The research that I have undertaken with teachers over the last several years addresses the question of producing classroom sequences from a completely different angle than that which I just presented. For, in my view, it is not possible to produce such sequences without also taking into consideration in the views and representations that practitioners hold of the process involved in conceptualizing the methods thus developed, their particular context of intervention, their routines of interpretation and action, and their constraints. For researchers in such a perspective, the construction of teaching situations (developing activities, problems, classroom interventions, etc.) inevitably proceeds through an understanding of the practice within which it develops, with such understanding considered as shaping the construction of these situations.

Collaborative research is thus founded on the idea that practitioners are essential in this process of producing knowledge (Desgagné, 1997).

Why make this choice, even if there is a wealth of past research with which to clarify certain selections of situations that could be fertile with respect to students' learning (in relation to, for example, place value, problem-solving and the meaning of operations, the transition to algebra, etc.)? In my view, it is not only a question of developing teaching situations that are relevant and rewarding in terms of learning, thereby contributing to an appropriation of knowledge by students (something that may be clarified by a previous analysis, of course), but also of producing situations that are viable in context. In these conditions, where teaching scenarios are selected by the various partners (teachers and researchers), they will appear as a legitimate manner of giving meaning to a teaching experience that has proven to be plausible and fertile with respect to learning and thus useful for guiding future actions. As a consequence, the meaning that the practitioner constructs in context, that he or she ascribes these situations - that is, in the exercise of the practice itself - becomes crucial. For these interpretations will be central to understanding the reappropriation that he or she will make of potential teaching situations.

So the idea of collaborative research in its origin is based on the idea of a certain knowledge to be constructed (in our case related to teaching situations) taking account of the experience and knowledge not only of researchers but also of teachers.

This position of the researcher is supported by a particular underlying conception of the practice and teacher work that founds the collaborative research approach.

Underlying foundations

A certain conception of practice

Schön's book, *The Reflective Practitioner*, published in 1983, constituted an epistemological turning point for those who felt the need to rethink the relationship between research and practice.

Schön demonstrated the limits of the dominant model based on technical rationality, which maintained a certain standardized conception of practice in which the tools provided to the practitioners (textbooks, situations, educational material, etc.) were designed to provide ready-made solutions to problems arising in practice (previously designed situations). In opposition to this model, he proposed another model, that of practical rationality. Schön's model foregrounded the role of indeterminacy that is part of the analysis of practical situations, and thus the need for the practitioner to exercise his or her judgment in a specific context.

According to this model, the complex reality of a practice resists complete standardization of the intervention to be carried out or of the professional's action; it

was the ambition of the technical-rational model to make practice valid for, and applicable to, every situation.

The body of mathematical education research focusing on teaching practices has grown substantially over the last 10 years. (Bednarz, Perrin-Glorian, 2003). This development confirms the complexity of practices, which cannot be reduced to the sum of their various parts (organization of subject matter, course preparation, real-time class management, corrections, and various actions having a longer-term impact related to the student's work, relationships with colleagues, the school, parents, etc.). It shows us the role of the unexpected in real-time management, both in terms of subject matter and of students' work, as well as the role of judgment in context exercised by a given teacher (adapting textbooks to the class, selecting situations and problems, day-to-day organization of work, etc.).

Finally, this body of research shows, in connection with this complexity, the stability and coherence of these teaching practices (see Bednarz, Perrin-Glorian, in press). The construction of practice-related knowledge (knowledge of curriculum; reinterpretation, selection and development of lessons, sequences, students' knowledge, etc.) is, in this instance, a situated activity (Margolinas, 2004). The teacher is guided by an underlying coherence, which sets in very quickly (Proulx, 2003; Lenfant, 2002). This result accords with other research conducted on teachers' experiential knowledge (Desgagné, 1994), which demonstrates that every practitioner develops an action-directed knowledge that is not arbitrary and that suggests, more or less tacitly, that he or she acts in a way that is consistent with an intended set of interventions that he or she constructs in relation to reference points, principles and an implicit theory. Desgagné (1994) investigated these interrelationships of coherence linking various theories of action in the mind of the same practitioner, with a view to explicating his or her more general theory of professional practice.

This openness to the practical judgment of the teacher (Schön, 1983, 1987) as regards the coherence (non arbitrary action-directed knowledge) and complexity of practices led, where research is concerned, to bringing a focus to bear on the meaning constructed by the practitioner in context.

In other words, this body of research opened the way to investigating and enhancing the appreciation of practitioners' knowledge of action, which entailed, among other things:

- drawing on theories of "action in context" (Lave and Wenger, 1991);
- drawing on qualitative methodologies in order to hear and interpret the "voice" of practitioners.

From the point of view of understanding the emergence of collaborative research, valuable light is shed on this transition to a practical rationality, considering the crucial role played by the practitioner's knowledge of action (i.e., a tacit type of knowledge to the extent that it has not been made explicit by research, but nevertheless a knowledge having an impact on the practice concerned) and the necessity of finding ways of hearing the practitioner's voice.

Fundamentally, this perspective on the role of practitioners brings into play a teaching actor who is assumed to be reflexive and knowledgeable, as well as a competent, situated social actor (Giddens, 87; Lave and Wenger, 91; Lave, 88; Wenger, 98) - that is, a bearer of professional ingenuity.

"Regardless of the 'worm's eye-view' these actors have of things, they are aware of the subtle chains of action, the series of decisions and choices, the calculations and



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expectations of the actions of which they are the agents and, in part, the authors” (Dubet, 1994, p 234).



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A certain posture assumed, accordingly, by the researcher

Accordingly, the researcher cannot claim to construct knowledge for the practitioner without, fundamentally, considering the knowledge that, with or without the researcher’s contribution, the practitioner constructs and develops throughout the course of his or her experience.

Hence the need, both epistemologically and methodologically, for the researcher to integrate the practitioner in the construction of practice-related knowledge. This participatory research already existed well before this transition (think of action research or the researcher-practitioner movement) but never has it been so concentrated on the internal logic of the reflexive practitioner, on the idea of better understanding the reasoning that supports his or her practice, and on the idea that the researcher position him- or herself as interpreter (in terms of both meaning and factual content) of his or her action: a teacher considered as a partner in the inquiry “with” whom one looks into the practice, who contributes in joint reflexivity (with the researcher) to the development of the practice.

This does not mean that in this process the researcher merely listens to the meaning constructed by the practitioner. First of all, there is a certain research project that, to some degree, delimits the process to be undertaken. These various projects are framed by the set of issues surrounding the construction of knowledge produced for teaching and learning in connection with school knowledge (i.e., the development of teaching situations that are not only fertile, but also plausible). In this group construction process, a variety of resources are brought into play.

I will take one example that I will elaborate on in greater depth, bringing out, on this occasion, the modalities of collaborative research, its outcomes and more specifically its contribution to research in mathematics education.

One example

Around the joint elaboration of teaching situations in mathematics in primary schools

The general theme

The collaborative research project issued from a need signalled by a team of Grade 1 teachers regarding problem-solving. The teachers, concerned about proposing to the children a problem-solving approach, as set out in the curriculum of the Québec Ministry of Education or in the educational project of the school board at that time, were somewhat at a loss when it came to availing themselves of the means with which to attain such objectives. Few avenues of intervention specifically targeting the subject had been proposed whereby they would be able to work with the children on developing problem-solving skills in connection with learning various concepts (number, place value, operations, measure, and geometry). Problem-solving is often associated with work involving problems formulated in words, and consequently, with teaching intended for older children. The questions that the teachers put to themselves were the following: Is it possible to adopt a problem-solving process with young children? What does such an approach mean, and how can it be developed?

These questions were posed at the origin of a project which initially lasted one year. The team was made up of four Grade 1 teachers, a remedial teacher, and two researchers, Louise Poirier and myself. Over the following three years, this project was continued in a more systematic manner around the development of mathematics

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teaching situations aimed at obtaining significant learning by young children (number, place value, operations, measure, geometry, problem-solving), while integrating teachers from different grade levels (grades 2 and 3).

The dual dimension of research and professional development

Designing situation-problems and an intervention scheme aimed at developing problem-solving skills among children was, at the outset, the linchpin activity making it possible to merge the interests of teachers and researchers. In the meetings that took place with the teachers, the situation-problems and the various alternatives available for using them served as a backdrop for *reflection on action* (i.e., *the dimension of professional development*). Discussions concerning the situations thus developed, the strategies used by the children, their lines of reasoning and difficulties, the management of the activity in context, and the underlying educational approach all constituted an opportunity to reflect on teaching problem-solving; in the process, ways of doing things and thinking about teaching children and their learning were all thrown open to questioning: What is a problem? What types of problems should be proposed? What do they enable me to develop? How can the children tackle these problems? How might their statements be used as a springboard?

This joint construction of situations in light of what occurred in class also fuelled the *production of knowledge in connection with the subject being investigated from various angles (the research aspect)*: the potential of situations developed in connection with the children's learning process. (In particular, at these meetings, the joint analysis of children's statements concerning the situations presented in class made it possible to throw some light on the skills and reasoning developed in the classroom, and on certain didactical variables that could have influenced this process). The recorded comments of meetings between researchers and teachers also contributed to identifying a viable and rich inventory of interventions in class (the teaching strategies were co-constructed, negotiated, shown to be viable in context among different class groups) and to highlighting the structuring resources (Lave, 1988) brought into play by the various actors involved in the construction. Finally, these meetings brought out the numerous modifications made to the situations and the justifications underlying them (i.e., the meaning(s) that the actor ascribes to the action).

The reflexive activity

The joint process of constructing teaching situations extended over four years and entailed, in each of those years, approximately one day of reflection each month. One day of assessment was also included at the end of the year in order to review the project in its entirety. Overall, the reflexive activity was conducted in such a way as to encourage a planned, regular alternation between classroom experience and review of this experience. Work was performed in groups using accounts of the in-class activities, the difficulties arising in context, the records of statements by the children, and the difficulties they encountered. This review of the experience took different forms and served as a starting point for developing a new intervention sequence. This reflexive activity thus developed around the meanings which the teacher developed in context and indeed imparted meaning to the situations or actions put forward.

The outcomes for the community of practice and for the research community

At the end of the project, teaching situations had been jointly designed by the teachers and researchers and the different avenues used had been clarified. This multi-year



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work resulted in the development of a collection of activities, of observation grids (making it possible to follow the children's development), and of classroom materials for the school. Adjustments and modifications were continually made, thus adding to the group memory of the work accomplished on these situations over time.

Several videos related to the situations tested out in class were also produced, in collaboration with the teachers; they were to serve as material with which to trigger intervention within the framework of preservice teacher education or the professional development days of in-service teachers.

As the projects were subsequently extended to other primary schools and other communities, a network of teachers gradually developed and continued to meet on a regular basis (without the researchers) in order to discuss activities.

With respect to research, video recordings of in-class situations, the records of students' statements, and audio recordings of reflexive meetings between researchers and teachers to review the situations served as material in the analysis of teaching situations and their potential for stimulating children's learning (Bednarz et al., 1993; Poirier and Bacon, 1996; Bednarz, 1996); in the analysis of the process of co-construction that took place and the respective contributions (Bednarz et al., 2001); and for monitoring the structuring of a teaching situation over time and the principles that guided this restructuring (Poirier, Bourdage, Bednarz, 1999).

By way of example, I will return to this last aspect in order to show the potential contribution of collaborative research to the development of knowledge in the field of mathematics classroom activities.

Restructuring of teaching situations in context and underlying principles

An initial situation: The "assembly line" developed with Grade 1 teachers (based on previous studies)

Starting from previous studies on place value (Bednarz and Janvier, 1984), the researchers proposed for discussion an "assembly line" type of activity to the Grade 1 teachers (of 6-year-old children). From this idea, an activity, whose main features I will outline, was first jointly planned with the teachers. For reasons of feasibility, the material had to be changed to something accessible and easy for the teachers to design (the initial idea was to do with boxes of cereal). The groupings had to be regular (at first, the packages of cereal were 6 to a box with 3 boxes per case, as is found in the store). For the teachers, this choice was influenced by their curriculum, involving the notion of regular groupings. This being said, the idea of several repeated groupings was used, even if, according to the curriculum, the children actually work on only one grouping in the Grade 1.

The objective was to prompt the children to construct a longer-term meaning for place value and various operations by presenting them with situations involving packaging, selling, buying, and sharing that led them to make and break up groupings.

Context: the teacher tells the children to organize a candy assembly line (or production plant). On this line, the candies are packaged for delivery to stores (once a child has 6 candies, they are packaged in a bag; when a child has 6 bags, they are put in a box; etc.).



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First part (simulation): The teacher chooses 4 children to work on the assembly line. One child counts 6 candies. When there are 6, he or she hands them to another child, who places them in a bag. When there are 6 bags, he or she hands them to a third child, who places them in a box. When there are 6 boxes, he or she hands them to the fourth child, who places them in a case. The teacher allows the assembly line to operate for a few minutes. Then she announces that the workday is finished and, with the help of the other children, checks what each “worker” managed to package. The other children can be questioned. The exercise is started over with 4 other children and with other teams. There are other opportunities to stop and ask questions about the different production lines: Who produced the most? The least? Why?

Second part (sales situation): The truck is now going to deliver the candies to the stores. The deliverer (one child chosen by the teacher) leaves the candy factory with x cases in his or her truck and stops at the store of a merchant (another child), who asks for x candies. The situation is repeated with different requests (from different merchants) of increasing complexity (e.g., no grouping to be broken up, one grouping to be broken up, two groupings to be broken up and co-ordinated, etc.).

Further variations. Adding up purchases (the merchant already had x candies in his or her store; how many does he or she have now?); comparison of what different merchants have in their store; order sharing (the deliverer must share everything that he or she has between two or more stores); sales (buyers come into the store to buy x candies; what must the merchant do to sell them the candies they want? how many are left over?).

Viewing the video of the situation reveals the appropriation that occurs

The video recording of a teacher using this situation shows the modifications that she made to the activity. There are no longer four children making up the assembly line while the rest observe. She set up two assembly lines, each composed of four children in the roles detailed above. She introduced a fifth role to the assembly line, that of a supervisor who oversees the workers. There are now 10 children involved in this work. The 18 other children are the future clients. Their role is to observe the workers, and when production is finished, they can buy from one or the other of the assembly lines. For this purpose, the teacher hands out a sheet of paper on which they can write their order.

An enriched, more complex situation

As can easily be seen, the situation has evolved, becoming enriched and more complex to manage. While the initial didactical intentions remain the same (the objective of working with groupings is still there), these *intentions are enriched*. The introduction of a notation, by means of orders produced by children, opens for the necessity to decode it by the seller and a possible exploitation of these different notations by the teacher. Some children make drawings while others use words; the sellers must decode these order forms. The teacher will take advantage of this to discuss the different notations used. For the researchers, these notations become material in the analysis of the role and evolution of symbolism (Bednarz et al. 1993).

The introduction of the buyers right from the beginning also enriched the intentions: the operations performed on groupings are now better integrated. Buying the material also leads the children to break up the groupings, which originally had only been planned for a later stage in the sequence (the various operations concerning groupings are thus better integrated in the sequence)



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The *management of the situation* was also considerably enriched, and became even more complex. There are now 10 children directly involved.

The role of the observers was made more precise. The other children still have the role of observer, as planned initially, but there is now something at stake: they are buyers. As buyers, it is in their interest that the workers do not make errors. The bags must contain six candies and not five, for example.

Reflexive review: principles (didactical and pedagogical) that guide the teacher

These modifications were framed (the reflexive meetings between researchers and teachers enabled them to explicate the changes) by the teacher's knowledge of her group of children and by educational principles.

First principle: The maximum number of children has to be active (as we can see in this verbatim)

L. "I noticed that at one point there were 4 who were working, while others were waiting around. The children working were active, but the others just watched. So, I decided to have 2 factories. I pretended I was the boss. I had 2 work teams, and I wanted the team that worked the hardest. ... activities more interesting for the children because they are more active at the same time. It's interesting for the children!"

The teacher had 28 children in her class; in her view, it was inconceivable that only 4 children be involved in the activity while the other 24 stood by observing. As many children as possible had to be involved in the process. For this reason, two assembly lines were set up to operate simultaneously, another role was created, and the role of buyers was assigned to the other children.

Second principle: Get children to get organized

The dimensions of observation and organization by the children are just as important to this teacher (as we can see in the verbatim quotes). We will find that also in other activities conducted all along the year. It is simultaneously for her a pedagogical and a didactical principle.

L. "So, I decided to have two factories...The first time was a total cock-up (sorry). Everything took forever. We tried to understand what had happened. One factory had operated more quickly.

But the others started to say 'we are going to watch them ... how can they be quicker than the others?' The children took the time to see why this factory operated faster. They were organized. By organizing the assembly line, they learned to get organized in other things as well...

Afterwards, however, they were in teams of 4 and I had 6 assembly lines, and then I wanted them to fill my order... We are going to see the reasons why it did not work in some cases. The organization you lacked. All you need to do is to have a good organization"

Third principle: a contest, a positive element, connected to seeing in different ways, listening to different points of view, observing...

The observation role of the other children followed from a view of competition as a positive component (at the origin of challenges)

L. "The children also saw how the others did things. They go see the

others' methods... how others did it.

There is also the competition, they are more interested in listening.

A contest means that the strongest are always interested because they can explain things to the others."

What lesson is to be learned from this?

I have used this example and the considerations preceding it to show how in-class practice and research are mutually enriching. For the teachers, such an activity provides a different perspective on place value and on learning it in combination with operations, putting the emphasis on important features at the foundation of our system of numeration. It also opens avenues of reflection concerning children's statements and about other ways of approaching this learning. For the researchers, the modifications implemented generate new avenues for reflection, new questions to ask about the restructuring of activities in context and the structuring resources brought into play by the teachers in this construction. Also, it opens a new perspective on children's statements (e.g., in the analysis of the situations developed). This activity could not have developed fully without the support of either the researchers or the teachers. The final product is thus original and unique.

I will return now briefly to the research model which emerged from the different projects conducted over the last years.

The collaborative research model that emerged from the different projects

A *reflexive activity* (conducted in various ways as was seen in the previous example) is at the centre of the model and acts as the linchpin of collaborative research. In it, researchers and teachers interact and jointly explore an aspect of the practice of common interest. This reflexive activity is based primarily on explication and analysis of situations of practice, seen from the perspective of the common interest defined by the project. In other words, the activity is conducted so as to encourage and maintain a sort of "conversation" (to borrow from Schön (1991)) between the teachers' practice and the reflexive review of the practice (between practitioners and researchers). Practically speaking, the activity takes shape through regular meetings between researchers and practitioners - in other words, through meetings that permit the creation of an "interpretive zone" around the practice that is the subject of the exploration.

This reflexive activity serves a dual function. It is an opportunity for professional development through reflexive review of the practice, with the objectives of clarifying, making explicit, and improving understanding of this practice - hence, of ultimately contributing to its restructuring.

It is a research opportunity, as this meeting zone (interpretive zone) constitutes material for analysis to be used for investigating a certain object of interest to practice-related knowledge.

As we have seen, these research efforts into mathematics classroom activities provide several insights including, in particular: over and above each of the projects, the angle provided by the situations and their potential for student learning; the angle provided on teaching "know-how" that was collectively constructed in terms not only of the process of co-construction around the mathematics teaching situations developed, but also of the insights gained into the contribution of the partners to this construction process within the space of mutual comprehension that was provided by



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the collaborative project (structuring resources); and the angle provided by the restructuring of teaching situations in context.

This research also had several outcomes at the level of practice, as we have also seen, through the material developed, the development of a network of teachers, the participation of teachers in inservice teacher education activities intended for other teachers or for preservice teachers.

In order to take the practitioner into consideration, the collaborative process seeks to bring about a meeting point serving to generate new knowledge in the lines of argument advanced by the actors involved. *Hence the idea of co-construction* (Cole, 1989) of knowledge in which the respective contributions of the various partners is turned to good account. Thus, in the case of the projects previously presented - in this space of reciprocal argumentation (Davidson, Wasser, and Bresler (1996) speak of creating a shared interpretive zone) - a series of arguments are developed around the manner in which various parties ascribe meaning to situations. Over the course of interactions, the teachers develop dimensions of their experience and compare them with the researchers' interpretations (the researcher has information that the teacher does not have and vice versa).

Beyond effecting a rapprochement between individual partners having diverse tasks and experiences, *collaborative research also entails bringing together communities of practice*, in the meaning defined by Lave and Wenger (1991), within which these individuals operate.

To be a researcher or a practitioner is also to be part of a group engaged in common practices, whose members (in the ethnomethodological meaning) work out between themselves a method of acting and thinking in their everyday affairs according to the constraints and resources that are their own. In this sense, collaborative research seeks to enable the intersection of two "worlds," if not the emergence of a new community. It proposes rapprochement of - indeed cross-fertilization between - two worlds in order to construct knowledge in the service of an informed or even enlightened practice.

Some remarks at this point

Collaborative research does not require practitioners to take part in tasks related to conducting research, in the formal sense of the term. It does, however, require them to commit themselves to exploring an aspect of their practice and to providing their understanding in context of the phenomenon being explored. This conception differs somewhat from what is usually meant by research collaboration (participation of practitioners in formal research efforts: in that case, the collaboration occurs only from the perspective of the phases peculiar to formal research and of the sharing of tasks related to these phases). Our model does not address collaboration from this perspective. Instead, its primary meaning lies in an exchange of services between agents who are part of different cultures and who do not have the same ultimate aims. It also derives meaning from a reciprocal influence between these agents. The researcher aims to produce knowledge that includes and takes into consideration the point of view of the practitioner and the constraints of the latter's context of action. Similarly, one could say that the practitioner aims to develop practices that will be clarified by the point of view of the researcher and by the conceptual framework that guides the latter's production of knowledge. From this perspective, collaborative research presupposes a reciprocal influence between practice and research (hence, the idea of co-construction within a shared interpretive zone).



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Contributions of collaborative research from the perspective of professional development of the teachers involved

Fundamentally, my various projects, which all have in common an effort to mediate between mathematics classroom activity research and mathematics teaching practice, develop knowledge of action (situations, mathematics classroom intervention strategies, a framework for analyzing children's and students' statements, a new way of considering the concepts, the curriculum, etc.)

- that is constructed around the point of view and voices of various social actors (mathematics classroom activity researchers, teachers) in reciprocal understanding around a shared project (e.g., development of problem-solving approaches among young children, intervention in secondary school classes that are weak in mathematics, etc.)
- within a mediating system (that supports the encounter between various actors), the locus of a reflexive process (of a questioning of practice)
- and that is productive of meaning with respect to action (contributing new perspectives on questions related to teaching mathematics, to re-engaging practice).

In the above, it is possible to glimpse the contribution of collaborative research to professional development of the teachers involved. Different components have been elucidated in the different projects, that I will present briefly.

- A deeper reflection on mathematical content (learning situated in practice). The teachers have the opportunity, during the discussions around the teaching situations and the productions of children, to improve their understanding of the mathematical concepts, as we can show in a collaborative project with Grade 4 teachers around the introduction of fractions (Bednarz, 2000).
- The nature of mathematical activity is laid open to debate. The collaborative research process is also the occasion to put in debate what mathematical activity means, as we can see in an example developed in a collaborative project with Grade 3 teachers about problem solving (Bednarz, 1998)
- A new way to look at children's statements (distance, nuance, judgment). Teachers have the opportunity, during the discussions about the teaching situations and productions of students, to develop new ways of looking at children's productions, to take a distance, to consider different ways to solve the problems. (Bednarz, 2000)
- Reflection on the didactical variables involved in a given task and their impact. The analysis of tasks goes far away from the superficial aspects to center on the reasonings that students could use to solve it, so as to permit them to see their complexity (Bednarz, 2000)
- Teaching strategies. Explication of arguments, underlying decision-making, opening up to other points of view. The reflection on the situations, and on their restructuration in context, as we have seen, show the different resources that are developed. There is an explication of arguments underlying decision-making, opening up for other points of view.
- An evolving relationship to teaching of mathematics. Changes took place in interaction over time, such as a changing relationship with teaching "know-how" (Bednarz, 1998)

- A new emergent community. A didactical approach in mathematics education focusing on explicitation and argumentation (Bednarz, 1998).



Conclusion

Collaborative research, as we have seen, opens new avenues for research in mathematics education, contributing to the production of new knowledge related to practice.

It also opens onto new avenues, at the same time, for reflection and action, on ways to support professional development of teachers, as compared to the classical models of professional development, which usually bear an implicit contract between those who propose the professional development and those who undergo training practices (i.e., the long-dominant technicist model, a model still implemented during curricular changes, in keeping with top-down movement).

This process situates teachers' learning in practice, engaging them in activities that are at the heart of their daily work. It creates opportunities that contribute to "enriching teachers' capacity for understanding and intelligent decision-making".

It is important to emphasize here that this questioning process does not concern only the teachers (a conclusion that could unwittingly be comforted by the perspective that has been used in my presentation).

This research requires, from the point of view of the researcher, the recognition that there is no monopoly of meaning—in other words, the recognition of the legitimacy of models and interpretations put forward by the teacher.

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