

PROFESSIONALS INVESTIGATE THEIR OWN PRACTICE¹

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This paper discusses the notion of researching our own practice. It presents two examples of such research from the activity of a study group on teachers' research that included teachers of all grade levels and teacher educators. One of these examples refers to mathematics teaching in the middle grades and another to pre-service teacher education. The paper concludes with an analysis of the potential and issues concerning this kind of research and its meaning in terms of the relationship between theory and practice.

Researching our own practice

This paper addresses the notion of researching our own practice, discussing the meaning of this concept, its potential value and weaknesses, and how it relates theory and practice.

Research is an important way of constructing knowledge. This is particularly true of research that practitioners carry out on their own practice. Besides helping to solve specific problems, it may have deep implications regarding their professional development and their educational institutions, changing patterns of organization, questioning the institutional culture, or challenging their relationship with the community. Knowledge produced by teachers and other professionals may also be of interest to professional and academic groups. So, conducting research on their own practice may be useful for those involved, for their institutions, and for the educational community at large.

Based on the perspective of Stenhouse (1975), who explicitly formulated the idea that the teacher may have an important role as a practitioner-researcher in curriculum development, Alarcão (2001) argues that every good teacher has to be a researcher:

Actually I cannot conceive a teacher who does not question the underlying reasons for his/her educational decisions, who does not question the reasons for his/her pupils' failure, who does not regard his/her planning as a mere working hypothesis to confirm or invalidate in the classroom (...)(p. 5).

Many teachers carry out reflexive and inquiry activity regularly, but informally. We argue that research on practice must be more than that. Of course, it does not have to assume all characteristics of academic research, but it must have some features that grant it the qualification of "research".

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So, what does it mean to do research? This process is at stake when we identify a relevant problem – theoretical or practical – and strive to find a convincing answer. Beillerot (2001) suggests that a research activity should fulfill at least three conditions: (i) provide new knowledge, (ii) follow a rigorous methodology, and (iii) be public. We agree that these conditions are fundamental. If our question was already answered, or if we knew the answer beforehand, then it would not be a research activity. Besides, research must follow a method, with some level of rigor, allowing those who are interested to understand and assess the process. Finally, research has to be made known to the community in order to be appreciated and evaluated. This is the only way its results and perspectives may be accepted by the professional group and, perhaps, by the general educational community.

These three conditions can apply to teachers' research on their own practice. However, they are very general. Only by developing a research culture and discussing cases will we be able to distinguish clearly what is in fact new from what is repetition, and to understand better what is methodical and rigorous. What is made public or not seems to be a lesser concern, although making the best of this task involves much consideration.

Often, research is characterized mainly by its methodology – condition (ii). For example, Lytle and Cochran-Smith (1990) underline the need for planning and data gathering and analysis procedures. However, our perspective is that these elements are not enough to characterize a research activity. It is also necessary to take into account the importance of framing questions and the way results and perspectives are made known and shared with peers and with the general community.

It is important to note that professionals' research on their own practice and the usual academic research have different purposes and must be regarded in different ways. Academic research aims at increasing academic knowledge, in areas and subjects the academic community establishes, arguing with persuasion (for this community). Research on practice carried out by practitioners aims to solve (or to shed light on) professional problems. Its main reference is the professional community. The two kinds of research have common but also specific features. Anderson and Herr (1999) and Zeichner and Nofke (2001) even suggest that research on our own professional practice may become the fourth paradigm of educational research, adding to the three "classic" positivist, interpretative and critical paradigms.

A study group on teachers' research

In Portugal, there are about 12 000 grade 5-12 mathematics teachers. There are also about 30 000 elementary school teachers who teach all school subjects, including mathematics, from grades 1-4. The Association of Teachers of Mathematics (APM), founded in 1986, has around 5 000 members currently. It holds national and regional meetings, and also meetings on selected issues. It publishes the teacher journal *Educação e Matemática* and the research journal *Quadrante*. Its curriculum "philosophy" is informed by ideas such as problem solving, technology, applications

of mathematics, and history of mathematics. The APM has regional groups, carrying out local activities. It also has working groups in topics such as geometry, history and mathematics, modelling, basic education, and technology. One of these is the *Working Group for Research* (GTI), created in 1990, that heads *Quadrante* and organizes an annual research seminar.

In April 2000, the GTI formed a study group, with teachers of all grade levels and teacher educators, to consider the topic of “The teacher as researcher”. For about a year the study group met about once a month to discuss papers and web sites. The foci of discussion were: What kind of problems may the teacher have interest in researching? What research can the teacher aim to do? What criteria may be used to make this research credible? Is this research activity compatible with the teacher’s other responsibilities? What training is required to undertake it?

Then, the members of the group decided to embark on a process of writing a book about their own professional practices. The aim was to provide a firsthand account of their experiences as professionals committed to research their own practices, as a first step to better understand them, and, if necessary, transform them. This book also intended to include some theoretical essays to help clarify the issues involved in this activity. In this process, the group’s focus changed from “Teacher as researcher” to “Researching our own practice”. This concept, which was met with great scepticism by academic-oriented mathematics education researchers, concerns not only teachers but also teacher educators and other educational professionals.

The participants began by proposing a title and an abstract, followed by a first draft of their contribution. Each text was discussed by all group members two, three, or even four times, to reach its final form. At times this process was somewhat frustrating – for the author who took the trouble of taking into account all the suggestions provided and for the other participants who had difficulty in agreeing on what was most important to suggest – but it ended up representing to all involved a fruitful exchange of ideas.

The final product is a book (GTI, 2002) that captures the participants’ research experience and results from a collaborative endeavour. It has three theoretical chapters (researching our own practice; collaborative research; reflection and teacher as researcher), five drawing on classroom experiences in grades 5-6, 7-9 and 10-12, about students’ investigations, differentiating classroom tasks, and using technology, and five concerning experiences in pre-service and in-service teacher education, focusing on developing innovative curriculum perspectives. Two of the authors were elementary school teachers involved in in-service mathematics teacher education.

Part of the experiences had already finished and some had been reported elsewhere. In these cases new narratives were constructed, aiming to show how these experiences can be regarded as research on professional practice undertaken by its actors and what they represent to their professional development. With respect to the researches still in progress, the aim was to produce some reflections based on the

emerging findings, without preventing their authors from producing subsequent reports with further findings, perspectives, and issues.

This process, based on rich and documented professional experiences, anchored in a clear goal and supported by the critical and stimulating environment of group collaboration, led the participants to produce written reflections that went well beyond all their previous accounts. Next we present two examples of such reflections.

Example 1: Investigating the typical pupil

This experience was undertaken by Olívia Sousa, a classroom teacher, in collaboration with a colleague in a 6th grade class (see Sousa, 2002). This class had nineteen 11/12-year-old pupils, who the teacher found friendly and interested. They had previous experience of working in groups and doing mathematical investigations. Assuming that, at this age, pupils are curious about their bodies, Olívia used this as the starting point of an investigation. She and her colleague drafted a script with questions to help pupils carry out their work autonomously. They discussed issues such as the classroom dynamics, their own role, time management and assessment. They decided to use five 90-minute blocks – three to carry out the task, one to write a report and prepare oral presentations and the last to present them. They also decided that pupils would work mostly in small groups. All class discussions would devote some time to sharing experiences and meanings. They carefully considered these moments, preparing questions to stimulate pupils' participation.

Class 1 focused on the preparation of questions to investigate. Pupils were challenged to consider how to characterize the typical pupil of this class and make conjectures about his/her profile. This information was to transmit later in a letter to a stranger. Pupils discussed what should be considered. They all indicated biological elements such as eye color, height, and weight. However, they raised many questions about the identification of social and cultural characteristics. Some groups discussed the typical profile. For example, green-eyed Mauro claimed that the typical class pupil had green eyes... When all groups had written down their conjecture, they shared it with the other groups. It turned out they shared very similar proposals, only disagreeing in their conjectures about height, weight, and preferences for using free time.

Reflecting about this class, the teachers felt that all pupils had worked well. They summarized the suggested characteristics and found that two – height and weight – required measuring. Considering that all pupils should do measurements, they added three similar characteristics. So, they assigned each group four characteristics to investigate, collecting data by means of a questionnaire, observation, and measurement.

Class 2 was dedicated to data collection. The teachers explained how the work was set up and provided each group with the overall plan. So all groups knew about their own task and the tasks of the other groups. They also received a script with a few suggestions about how to frame the specific questions to ask and how to organize data collection. The identification of the proper techniques of data collection was

straightforward. The preparation of a form for data recording was also an easy matter. The second part of the class was for data collection. The teachers provided a scale and several tape measures and pupils got the weight, height, hand-to-hand spread, shoe and hand size. They were quite surprised with the efficient way pupils organized themselves to collect all data. In their post-class reflection, the teachers felt they had underestimated pupils' organizing abilities, concluding that they have initiative and are able to get organized when they are solving problems of their interest.

In class 3 data were processed. The statistics concepts had not been taught to these pupils previously. Even so, the teachers decided not to address them explicitly, thus requiring pupils to resort to their previous knowledge. That slowed down data processing. As in the previous classes, a script with leading questions and a statement about average, median, and mode was provided to pupils. Finding maximum and minimum values and assessing whether data was concentrated or spread was easy. The identification of the mode did not create problems. Pupils did not know about this term but showed some grasp of the concept when they discussed the typical eye color. With some support, most pupils were able to compute the average. In the first class, it was apparent that some of them knew about this concept, when they conjectured about the typical pupil's height. Finding the median took more time. Some did not order their values, thus making this determination more difficult. Some pupils did not take into account the repeated values and others identified median as the average of maximum and minimum. At the end of this class the teachers summarized what the groups had done and realized that some had learned new things deserving to be shared with their mates.

Class 4 was a reflection of the work carried out so far. Pupils contrasted their ideas and shared what they had learned about the characteristics of the class and about statistical concepts. They also discussed what to do with repeated data. The group that computed the median as the average of extreme values explained their approach. They had found the difference between the maximum and the minimum values and then divided it into halves. Adding that half to the minimum or subtracting it from the maximum yielded the same and they concluded that was the median or "middle" value. The other pupils found this idea quite acceptable. With the list of the ordered data written on the board it became apparent that this process yielded a different value. Pupils finally agreed that the average of the extremes does not represent the median, since this is an actual value of the variable. Then, the teachers asked pupils that had constructed a stem and leaf diagram to show how to do one. The same was done by a group who had made a spread graph. No time was devoted to explain the construction of bar graphs since pupils found that unnecessary.

At the end of the class, the teachers concluded that assigning four characteristics to each group made data processing too cumbersome. It would have been more efficient if each group only had two variables, one quantitative and another qualitative. They also considered that their option to not explain the statistical concepts was adequate

since pupils were able to learn from their needs and build on previous knowledge. This stage was long but they felt that the result was positive.

Class 5 included the preparation of reports. Pupils made graphical representations of their data. In the second part of the class, they prepared the oral presentations and written reports, based on a script with the following points: (i) members of the group, (ii) questions under investigation, (iii) methodology, (iv), results, and (v) conclusion. Pupils drafted their reports and considered how to present their work, deciding to use overhead slides. They had no time to finish them and it was agreed that they would be concluded later. In each group there was a pupil with a computer at home, so the final writing of the report and the overheads was not a problem.

In class 6 pupils conducted the oral presentations. They were a little nervous and worried. The teachers let them solve last minute matters and the presentation began. The pupils were interested in the presentation of the other groups. When they finished, the presentations were discussed, in order. Some groups asked their colleagues to clarify how they had collected data. The most controversial question had to do with the number of blonde pupils in the class presented by one group. It became clear that the concept of “blonde” was not the same for everybody and they concluded how important it is to have clear operational definitions. The time set up for discussion was too short to address these issues and to write the profile of the typical pupil. This was done later, in another class, when pupils wrote the letter to the stranger and reflected about this activity.

At the end of this experience, the teachers evaluated the work carried out. They considered that this activity allowed pupils to work number and statistics concepts in an integrated way. Decimal numbers, arising from measurements of the human body, acquired a new meaning. Their manipulation in a significant context, involving comparing, ordering, grouping, and operating, led pupils to improve their global understanding. As for statistical concepts, the work done with different kinds of variables and ways of collecting, organizing and representing relevant information promoted an understanding that goes much beyond its simple memorization. The exploratory way of addressing the statistical measures of average, median, and mode proved to be a good strategy.

The teachers also reflected about pupils’ learning regarding the steps in a research process. Pupils collaborated in formulating questions, although some did not have a strong participation. Pupils surprised the teachers in the stage of data collection, because of their organization. In the final stage, there were some productive discussions. The teachers also concluded that statistical investigations are a good way to address social, environmental or health issues. Discussing the characteristics to select, formulating conjectures regarding the typical pupil and analyzing results were important argumentation activities for their personal development. They developed their critical and reflective abilities, essential for an active citizenship.

The pupils indicated they had enjoyed the activity. They found it interesting and fun, especially collecting data. One group wrote in their report: “at the beginning we thought that this work wasn’t very interesting, but then we began to enjoy the practical side of the work because we measured, observed and asked...”

The teachers concluded that the task was to be used again but more simplified. They wanted pupils to study different kinds of variables and use different methods of data collection and ended up giving each group too many variables. This yielded a large amount of data to process, requiring more classes than foreseen and thus taking up some of the time planned for reflection and debate. As the two teachers worked together, they could profit from the potential of professional collaboration. As they prepared classes they discussed possible events and reflected about ways to deal with them. By the end of each class, the joint reflection helped them to understand how pupils were living the experience and to adjust plans, whenever necessary.

Example 2: Learning to teach through investigations

This experience was undertaken by Helena Fonseca, a university teacher educator, in an optional semester course of a mathematics teachers pre-service program (see Fonseca, 2002). Participants had completed their mathematics studies in the first three years of the program and were now in the fourth year. The goal of the course, named *Thematic Seminar*, was to study about investigations in mathematics and in mathematics education.

Helena had been involved in a curriculum project about mathematical investigations and became aware that this approach is very important in the school curriculum and, consequently, future teachers have to learn how to implement it. She made a plan of the course, identifying the aims, the topics to include, and the papers and other materials to use. She thought about following the methodology she had used before in educational courses: a short presentation of themes by the lecturer, small group discussions based on papers previously read by students, class discussions, and one or two extended projects. The curriculum was organized in three segments: (i) investigations in mathematics, (ii) investigations in the mathematics classroom, and (iii) investigating a mathematical issue. Each of these segments lasted for four weeks (about 8 two-hour classes).

Before the semester started, Helena discussed her plan with a colleague and decided it had to undergo a deep reformulation, not in terms of content but in terms of perspective. As this was a course related to investigations, it could move as far away as possible from the usual style and be framed within the logic of investigative work. Pre-service teachers should learn as much as possible about investigations by doing investigative work themselves. So, the main idea went from “learning about investigations” to “learning by doing investigations”.

The first segment focused on *Investigations in mathematics*. The pre-service teachers dealt with the following issues: (i) what are mathematical investigations? (ii) how do professional mathematicians investigate? and (iii) what do professional

mathematicians investigate? Organized in small groups, they did some bibliographic investigations and searched the Internet. Meanwhile, in the classroom, they discussed a few papers provided by the teacher related to the work of professional mathematicians. This work culminated in the presentation of discoveries made by different groups of pre-service teachers. Helena chose these topics because she feels it is important that pre-service teachers know how professional mathematicians investigate, that is, how they do mathematics. The three years of mathematics training usually provide them with very little knowledge about this aspect. The work developed by pre-service teachers during this first segment was their first contact with the inquiry process, which would be present throughout the rest of course.

The second segment dealt with *Investigations in the mathematics classroom*. Pre-service teachers were challenged to research about investigative work in mathematics classes and what teachers think of it. They should consider experiences that had been carried out, address their potentialities and difficulties and possible differences between practice and theory. This segment addressed four key issues related to investigative work in the classroom: (i) learning outcomes; (ii) classroom environment; (iii) teacher role, and (iv) tasks. Some papers about these issues were read and discussed. Pre-service teachers also read narratives of classroom investigations and discussed tasks, trying to decide whether they were investigative or not. Using e-mail, they interviewed a teacher who had already done some investigative work in her classroom. They analysed the Portuguese mathematics curriculum in order to know how it considers investigative activities. And, finally, the participants constructed a report framework and assessed reports written by pupils as a result of their investigations. At the end of this segment, they reflected about theory and practice, striving to understand what had worked out in classes. For Helena, this second part of the course had a less investigative logic than the first one. For her, this logic followed the need to focus on many issues, as pre-service teachers were far from classroom practice and needed some guidance as to how to analyze all these aspects.

At this point, the pre-service teachers had already explored and discussed four investigations proposed by Helena about geometry, functions, and numbers. She felt their involvement in exploring investigative tasks could help them to develop an investigative attitude and wish to implement such activity with their future pupils.

The last segment intended to represent an experience of *Investigating a mathematical issue*. So, the task for pre-service teachers was to choose an elementary mathematical theme, create a situation, investigate it, and present proposals about how it could be used in the classroom. This work ended with the construction of WWW pages about themes such as the Pascal triangle, the golden number, prime numbers, equations in secondary school, triangular numbers and powers. In this third segment, once again pre-service teachers had a remarkable investigative activity. Some of them focused on the properties and relations about the theme and others focused on aspects related to the teaching of a theme. Again, they used different books and the Internet. The

research carried out allowed pre-service teachers to select and adapt investigative tasks, which they may use in their classrooms in the future. They explored those tasks in depth and wrote guidelines for teachers who might want to implement them.

Helena asked pre-service teachers to write a reflection about the work undertaken in the course. These reflections show their appreciation for the role of discovery in mathematics learning and for what that means for teaching practice:

This new teaching approach allows pupils to find mathematics much more interesting, feeling like little mathematicians showing their joy in discovery. It is this joy that the teacher must cultivate, letting them (...) discover the mathematics that they are supposed to learn. It is true that investigation classes are a challenge to pupils but is also a fact that they are also a challenge to teachers!

Reflecting on this course, she also felt it was quite successful. Most of these pre-service teachers had a schooling framed by traditional mathematics teaching, both in elementary and secondary education and in university mathematics. So, at the beginning of the course, their perplexities about what to do in an investigation were quite evident. They had very limited knowledge about investigative tasks. At the end of the semester, a more confident attitude regarding this kind of activity was clear. After one semester, they could already grasp the potential of investigations and had become aware of the difficulties they could face when using them in classrooms. Helena considered this course limited because pre-service teachers did not have the opportunity to teach investigative classes to real pupils. Without this, it is difficult to say whether they are prepared to carry out such work in their professional practice. However, not too much can be achieved in a single course, but this one represented a giant step for pre-service teachers who had no former experience in this kind of work. Helena felt that the approach used was quite successful in promoting participants' learning. Pre-service teachers could learn a lot through such an investigative mode and she started wondering how she could use it in other university courses as well.

Conclusion

In this paper, we presented researching our own practice as a possible variety of research, with its own objectives and characteristics. Underlying this is the notion that research is a general form of construction of knowledge and that academic research is the more widely known variety but not necessarily the only one.

What makes these studies relevant for professional practice? Olívia, in the beginning of this process, wanted to strengthen her ability to carry out an open and exploratory type of teaching, but she did not find statistics an interesting topic for her purpose. Her trajectory, involving readings, discussions and collaboration with colleagues and her academic supervisor, the conception and conduction of an experience in the classroom, the recording of data concerning her perceptions and the activity of her pupils, her analysis and sharing it with others, represented a very significant evolution concerning her issue and a deep change in the way of regarding statistics in

the curriculum and in classroom practice. This is a study that is quite documented, representing a significant contribution to the professional culture of Portuguese mathematics teachers. Besides, it may provide interesting leads for further studies by academic researchers.

Helena, while carrying out this experience, faced a key issue in pre-service teacher education – the coherence between the perspectives presented to the participants and the practices enacted in the classroom. This became a serious problem as she was teaching a course based on an innovative curriculum perspective. Once she identified the problem, it was necessary to construct a solution and check its reasonableness. She paid special attention to the reactions of pre-service teachers and asked them for reflections and comments that gave her an idea about how they were living this experience. The presentation of this work in professional meetings and its writing helped her clarify the key questions that were at stake and make this experience available to the relevant community, in this case the mathematics teacher educators. Given its novelty (in the Portuguese context) and relevance, this is an important contribution towards the field of pre-service mathematics teacher education, that can stimulate similar initiatives from other teacher educators in Portugal.

These two experiences were different in a number of aspects. Olivia had an ongoing work, with sixth grade pupils, whereas Helena carried out her experience in a pre-service course, one year before writing about it. Olivia worked collaboratively with a partner teacher in a unit of 5 class periods, while Helena was the only one responsible for her one-semester course. However, their experiences shared some common features. Both concerned the design and carrying out of a curriculum initiative focusing on the idea of investigations – a rather innovative perspective. Both included several methods of data collection, including researcher's notes and participants' written work. And both were made public through the process of writing and discussing with other members of the GTI study group. These two experiences show that this kind of research is able to tackle relevant problems of professional practice, produce results of great interest to their authors and other professionals, and can be undertaken at a level of rigor that is enough to deserve credibility from this community.

Researching our own practice is a perspective related to the traditions of the teacher as a reflexive practitioner and to action research. In Portuguese mathematics education, this is a rather new perspective. It involves reflection but goes far beyond it. The concern to act does not surpass the striving for understanding. This is a field that will require a long journey in the realm of theory, strengthening its epistemological foundation, and in the realm of practice, where there is ample room for a fruitful collaboration between teachers and mathematics educators.

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