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CONNECTING RESEARCH TO FRENCH MATHEMATICS  
TEACHER EDUCATION

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INTRODUCTION

On what basis should we train future teachers of high school mathematics? In the search for an answer to this question we studied the practices of both newly qualified and experienced teachers in the classroom. In this report we present an overview of two surveys that focussed on teachers' classroom practices. The first survey provides an overview of the difficulties experienced by beginning teachers. The second survey provides a more detailed description of the classroom practices of experienced teachers. We then consider the hypothesis that it would be useful for teachers to have a careful description of the mathematical reality they face in the classroom. Finally, we propose a research project on teachers' professional development that is based on this hypothesis. But first we provide a brief account of the training of future collège (middle school) and lycée (high school) teachers.

*Basic (Theoretical) Teacher Education*

In France, the training of future mathematics teachers usually takes place in the five years following the baccalauréat which occurs at about age 18. Three of the training years are spent at a university, and the remaining two years are spent in an IUFM, an Institut Universitaire de Formation des Maîtres. During the first two years at the university, students study physics or chemistry, computer science, and mathematics. The mathematics syllabus is the standard syllabus required for all students and includes classical linear algebra and analysis on  $\mathbb{R}$  and  $\mathbb{R}^2$ . During the third year, students specialize in their respective subject area, for example, mathematics. They begin to study topology, differential and integral calculus, and, as an option, either probability, complex analysis, or numerical analysis.

The fourth year, which for the majority of future teachers is the first year at the IUFM, is still devoted entirely to mathematics. During this year students prepare for a competitive exam, theoretical in nature, which is



required of all future teachers. The written examination covers problems from the students' university studies. The oral examination, on the other hand, covers the latter part of the high school mathematics curriculum but remains theoretical in nature. It is only during the fifth year of study (second and final year at the IUFM)<sup>1</sup> that there is any real consideration of what the profession of teaching involves.

### *First Steps into Practice*

The beginning teacher (called a student teacher) is responsible for teaching one class from end of collège or the beginning of lycée (8th or 9th grade) and is helped by an experienced mathematics teacher in the school, the tutor. The tutors are generally volunteers but have the approval of specialized mathematics inspectors. The student teachers' training, called the teaching practice, is accompanied by training periods in other schools and in teacher training centres where they receive sessions in pedagogy. Unfortunately, it is accepted by many that a thorough knowledge of mathematics is enough to teach the subject. Similarly, training that does not specifically concern mathematics is often not held in high esteem by most student teachers. So, we can rightfully ask whether the training is effective, whether it produces teachers who are able to adapt to the new generations of pupils and to new technologies.

Given these conditions, what kind of research should be done on the training of future mathematics teachers? We decided to start by examining examples of teachers' classroom practices before looking at the training itself. This focus on what teachers do corresponds to what Schön (1987) called the *professionalism* of the job of teaching. We begin our discussion with research that involves novice teachers.

## RESEARCH WITH MATHEMATICS STUDENT TEACHERS

First, we will highlight the naive points of view of student teachers and their tutors. From these findings, we realize that something is missing as beginning teachers remain preoccupied with daily, practical concerns but are unable to see the precise link between how they teach and the learning experiences of their pupils.

In 1994–1995 we surveyed student teachers and their tutors. We received 71 questionnaire (see Appendix) replies from student teachers 1 month after they took their first job and 40 replies after 8 months of teaching. (The respondents to the two surveys were not the same people.) We also received 117 replies from tutors although they were not neces-

sarily the tutors of the student teachers who replied. Four interviews which we will not mention in detail here were conducted.

Four types of results emerged (cf. Robert, 1995a, 1995b). One of the obvious findings was the great diversity of responses. The student teachers did not all come from the same background which perhaps accounts for the apparent discrepancy in what they perceived the ideal training to be. For example, a few wanted a course in child psychology which was less superficial, whereas most wanted theoretical courses to be abolished completely. Nevertheless, there were some recurring themes in the responses. We will focus on three of them: the success of the practical part, difficulties identified by the teachers and their tutors, and the teachers' failure to mention pupils' learning experiences.

#### *The Success of the Practical Curriculum*

There is nothing new about preservice teachers applauding school-based experiences but it is interesting to note how unanimous this perspective was. All but two of 71 respondents indicated that the student teachers felt that what really helped them solve their individual difficulties was the fact that their tutor was there to help them cope. Over one third of the student teachers responded that their tutors had helped them with their lesson preparations; about 25% mentioned that their tutor helped them with classroom management problems. As one student teacher put it, "The tutor gives us hints as to how to maintain peace and quiet, help on lessons, tests." On the other hand, the courses at the teacher training centers were considered too vague, too general, and too theoretical. "What can we do with all this?" wrote one student teacher.

As for the tutors, they were quite satisfied with the usefulness of their role. They felt that their student teachers progressed nicely during the year, a perspective that justified their existence. In more than three-fourths of the questionnaire responses, the tutors maintained that their remarks about teaching appeared useful to the student teachers.

#### *Difficulties Identified by Student Teachers and Tutors*

A common problem mentioned by the student teachers (49% on the first questionnaire and 45% on the second) was that of time. They had difficulties estimating the time it would take their students to finish a problem. They also had a poor concept of how to allocate time to cover chapters and the curriculum.

Other problems identified included discipline (mentioned by 54% of the respondents on the first questionnaire and 75% on the second questionnaire), and dealing with mixed ability classes (44% responses in the first

questionnaire and 40% in the second). Almost 25% of the student teachers also mentioned problems related to their voice, the use of the board, and making their presence felt in the classroom. Close to 10% mentioned problems related to the choice of content and to instructional moves that tended to focus on the following concerns.

- the balance between teacher lecture and the pupils' individual work,
- the selection of appropriate activities, and
- the construction of pupil's tests.

New difficulties appeared in the second questionnaire. Student teachers found it difficult to create activities that were feasible for the pupils (30% of the responses). It seems that taking pupils into consideration was more of a concern now than at the beginning of the year.

The student teachers' difficulties in organizing classroom activities was mentioned by 36% of the tutors. The tutors saw a poor balance between lectures and activities. The tutors recognized the progress made in the student teachers' use of time and in the consideration given to the pupils. Nevertheless, problems related to discipline remained the most dominant concern.

#### *A Missing Feature: The Pupils' Learning Experience*

Perhaps the most common theme mentioned by both student teachers and tutors was that the basic necessities of teaching include pupils listening to the teacher and following the teachers' instructions. Pupils' success in learning was referred to less frequently except when tests were concerned. Learning was seen as a vast on-going process; the way pupils acquire knowledge and obstacles to that learning were not mentioned in the responses. Moreover, tutors hesitated to talk about the way their pupils learned so as not to impose their own points of view which they considered personal, non-proven, and even non-legitimate. The following response from a tutor indicates this missing element.

It is illusory and even harmful to think that we impose our own model on the student teacher. Our job is to allow the student teacher to find himself given what he or she is and what he or she wishes to be. We do not do this in the course of a theoretical debate on the subject, but when precise questions arise which show there is something deeper underlying, which is problematical, we must be open to discussion.

Furthermore, when questions pertaining to the way pupils learn were raised during the theoretical part of the course, the students held this part in such low esteem that we can be skeptical about the effect the discussion had in the long run.

In conclusion, it can be said that the training period in real classes corresponds to what the students want. Beginning teachers were satisfied with the practical part of the course and generally managed to overcome the major difficulties they faced in their teaching.

There was very little discussion about the precise elements of the pupils' learning experiences. The criteria adopted by the student teachers remained linked to a somewhat superficial analysis of the way a class works. Imitation of previous generations of teachers remained the norm. Is this sufficient to answer the new challenges of education, such as its democratization or the need to adapt to a very different generations of pupils, or to a renewal of course content?

### RESEARCH WITH EXPERIENCED TEACHERS

After these comments, we must ask ourselves some general questions. How do more experienced teachers deal with the way their pupils learn? How do they adapt to their classes? Is there some sort of benchmark that guides the tutors' judgement and advice? What conclusions can we draw from this for teacher training? With this in mind, we recorded lessons of four teachers who were all teaching the same content, the introduction of vectors and functions. The teachers taught in four different average schools. We then analyzed these lessons. A brief summary of our analysis follows.

#### *Common Structures in the Teaching of Mathematics*

There is some evidence that the teachers varied their style of teaching based on the content taught. For example, when teaching vectors, the teachers tended to exhibit a greater variety of classroom activities than when teaching other topics. Nevertheless, all lessons were constructed basically along the same lines without much variation. They began with exercises (either revision exercises or introductory exercises) and then proceeded to a presentation of new material that was later applied in intermediate exercises. What variations did exist consisted primarily in the quality of the exercises at the beginning and the links made between the exercises and the teacher's presentation. In summary, there was little evidence to suggest that the teaching of mathematics was modified based on what pupils were experiencing.

It seemed as if there was some benchmark that guided teaching, in part encouraged by the use of textbooks, in part in the early models of the tutors. The norm of covering exercises, presenting new material, and assigning

exercises seemed unproblematic to the teachers. This way of functioning was far more prevalent than a differentiated reflection in which teaching is based on constructivist principles.

#### *Classroom Discourse*

We found that pupils were seldom asked questions that addressed the structure of a mathematical topic. We maintain that this phenomenon could explain the difficulties pupils have in organizing their knowledge. A special effort should be made to encourage teachers to include such structuring questions in their teaching.

We noticed important differences during the lessons regarding discourse links. Whether these links were elements that structured and contextualised mathematics, or lead to reflection, their frequency depended on the teacher and the lesson. For example, sentences about the above-mentioned links made up 21% to 39% of teachers' discourse during parts of the lesson devoted to vectors.

#### *Approaches to Teaching*

Three different approaches to teaching mathematics prevailed. These approaches were not specific to any one teacher but to a lesson, even if each teacher had some own favorite ways of teaching: teacher inventiveness, textbook domination, and the hazy approach.

*Teacher inventiveness.* Teacher inventiveness corresponded to lessons in which the teacher made a variety of links, especially between the mathematics of the exercises and the decontextualized properties of mathematics. There was a lot of non-direct speech that did not constitute formalized language. There were well prepared and carefully chosen exercises that were presented to the pupils. Pupils were asked about their results and their reasoning.

Lessons contained a large amount of mediation stemming from a particular understanding of the mathematics to be taught. From our perspective, this was a particularly useful part of a teacher's expertise. For example, we think that knowing the status of the notion of vectors in the syllabus, or being able to ascertain the level of activity one expects from the pupils in an exercise can widen the teachers' choices for their preparation and also for the way in which the lesson can develop.

*Textbook domination.* Textbook domination referred to teaching in which the teacher did not go beyond the exercises in the textbook. Teachers did not add their own comments that could help pupils anticipate or at least

start to think; there was little structuring and the new elements were not carefully prepared. It was as if the teacher was an excellent pupil who did not deem it necessary to prepare the background.

*The hazy approach.* This last approach was difficult to define. It was as if the teacher's project was so vague that she frequently allowed herself to digress on any occasion, without any real grasp of the pupils' level of comprehension. This kind of waffling was rarely specifically connected to the mathematical content.

## IMPLICATIONS FOR TEACHER TRAINING

Let us now consider several implications of our research for the training of teachers.

### *General Perspectives*

Our research and experience led us to the following conclusion: Training must take into account the importance of the gradual change in teachers' relations to mathematical knowledge and also the extent to which various training courses are being recomposed. The need for beginning teachers to take into account the pupils (one of the essential components of the new relation to knowledge) and to realize the importance of the gestation learning period of pupils requires an internal revolution in the way of teaching mathematics. This revolution can be transmitted neither solely on the job nor in the teacher training centres. Various research reports (Crahay, 1989; Grant, Hiebert & Wearne, 1998) have already emphasized the difficulty teachers have in changing their practice. The way beginning teachers acquire their practice is therefore of capital importance.

The questions that teacher trainers can ask themselves are quite simple. How can one help or speed up this revolution in training without at the same time denying the validity of, or reducing the importance of, all previous university training? The researcher's challenge is to determine what sort of research must be done in order to find an answer to questions of this kind.

We have seen the difficulty teachers have with presenting mathematics in such a way that linkages are formed and students are enabled to appreciate the structure of mathematics. We suggest that in order to train teachers, it would be useful to specifically address this approach to the teaching of mathematics and to couch the problems in the context of actual

classroom practice. Specifically, we propose the following approach to teacher education:

- examine possible settings and linkages when teaching various mathematical topics,
- examine the different cognitive levels that different kinds of questions evoke, and
- examine the different discourses that may be involved in teaching this way.

These considerations may enable us to consider the teaching of mathematics in a new light. It will help optimize a certain number of variables that correspond to dimensions we consider important in didactics that influence the learning of mathematics. It can help us analyze practice and transpose into actual classroom practice suggestions for lessons that are based on general theoretical choices.

#### *An Example*

Teachers, when choosing the wording of the problems, can be encouraged to consider whether or not an activity that adapts knowledge is being assimilated by pupils. Or teachers can ask whether they need to ask questions in which no help is given, forcing the pupils to ask themselves questions that encourage pupils to use knowledge they have at their disposal. Then, when studying functions, for example, the teacher could ask the pupils:

- to find the interval over which the function is defined, and then to draw a graph of variations by studying the limits, and
- to study a situation that can be modeled by the function.

By considering the introduction of content we can help student teachers think of better ways to present the content to pupils. One could start by asking the pupils to solve a particular problem that will help them conceptualize the content. This kind of systematic analysis of teaching could help student teachers enrich certain moments of teacher discourse during lessons especially at moments when they are trying to install processes of mediation.

#### *A Research Project*

In 1999, we initiated a research project on the topic *Constructing Word Problems That Correspond to Given Constraints*. We are working with high school teachers on various ways they can construct word problems that can be modeled by the same mathematical situation. We are examining

different constraints that lead to making choices. We intend to work with teachers in a variety of mathematical situations of their choice to investigate the effect of these constraints. It is this kind of analysis that makes up the professional tools that can become the focus of teacher training. Teachers will then experiment with these wordings in class and we will make an assessment of the ensuing practice.

## APPENDIX

### *Questionnaire for the Beginning Teachers*

1. What was useful in your training?
2. Describe the main difficulties you met this year:
  - when preparing your lessons;
  - during your lessons;
  - when evaluating your lessons.
3. What was the main help you received this year?
4. What questions on teaching remain without answer?
5. What was the specific help of your tutor?

### *Questionnaire for the Tutors*

In the first part of the questionnaire, the tutor had to elaborate on some external conditions of teaching. Then he or she had to answer many questions of which we provide the following sample:

1. What questions did you ask your student teacher?
2. What were the main difficulties met by your student teacher? Did they persist during the year (preparing lessons, during lessons, to evaluate lessons)?
3. In which way did you help your student teacher (coming in his or her classroom, or inviting him/her or her into your classroom, or in another way)?
4. Did it depend on mathematical contents?
5. On what subjects did you disagree with your student teacher?
6. What was the most difficult aspect for you in providing help?

## NOTE

<sup>1</sup> For more details regarding the program of the IUFM, see Henry, this issue.

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