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Training primary school teachers through research in mathematics' didactics

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In order to become school teachers, since the last reforms in teacher education in France, the student teachers have to obtain a master's degree, including a research report in a field linked to education, or to the disciplines taught in school. In this study, we analyse the content and methods of an initial course in research in mathematics education, building some tools to assess how such a course can influence the beginner teachers' practices in class during the first years after their training.

Keywords: Teacher education, research initiation, practices, primary school.

In France, teacher training has gone through many changes during the last five years. The main result is that, since 2010, teacher training became part of a university master's degree, including some periods of internship in classrooms, the preparation for the competitive examination which serves to recruit teachers, and, what is new, a research course that leads to a research report on a field linked to education or a discipline taught in school. This initiation into research is supposed to help the prospective teachers in their professional development, reading and understanding results from research articles. Adapting findings for teaching should allow the teachers to reflect on their own practices.

Each university makes its own choices for the contents of the master's program for teachers, within the national guideline for the number of hours for the 2-year training. In the University of Créteil, near Paris, where the researchers of this report are also school-teacher educators, the time allowed for the research part of the training is rather important (120 hours out of 770 hours in total, spread over 2 years), compared to the training programs of the other French universities, but also compared to the time allowed for the rest of the training (professional and disciplinary content). The report requested from the student teachers after 2 years can be considered to be a research report, as it has to follow the same rules as any research report in our research field (a research question and hypothesis, an experiment in class, citation and bibliography norms) even though we probably are less demanding than with students following a research program. This part of the master's represents 34 ECTS out of the 120 needed for the diploma, including 10 ECTS for the report itself.

We are teacher educators for school teacher training (for teaching pupils from 3 to 11 years old) and particularly we run the course for research in mathematics education, which we designed a few years ago, after the reform. As researchers (Nadine Grapin, Brigitte Grugeon-Allys, Julie Horoks, Eric Mounier, Cécile Ouvrier-Buffet, Monique Pézard-Charles and Julia Pilet, all from the LDAR) we are also trying to assess how this course affects the professional development of our students, and find ways to pinpoint the effects of this initiation into research in mathematics education on their practices while teaching mathematics during the early years after the end of their training.

In order to study the effects of the training, we need theoretical and methodological tools to analyse both the content of our research course and the practices of the beginner teachers who were our former students. We present here the different sets of tools that we have developed for this purpose.

RESEARCH QUESTIONS AND THEORETICAL FRAMEWORK

To study teacher training

Some studies in France have already tried to assess the effects of initial training, for school teachers (Butlen et al., 2003) or high-school teachers (Grugeon-Allys,

2008; 2010). But these studies were carried out before the many reforms of teacher training and the introduction of research in the training program. Since 2010, the content for the training has changed in various ways depending on the universities (Grugeon-Allys, 2010). Note that we refer mostly to studies that were carried out in France, as we believe that the institutional and cultural context has an influence on teacher training and teacher practices.

We are trying to build tools to assess the effects of teacher training on professional development, and, in particular, the (potential and real) effects of training teachers through an initiation into research. We define some reference grids, linking the content of the training to the teachers' practices that are aimed for, and being able to relate the evolution in the teachers' practices at the beginning of their career to the dynamics of the training program. We are also looking for consistency among our former students' professional practices that we could link *a priori* to the training that we provided, in terms of knowledge as well as in terms of strategies used to share this knowledge.

The general question that we are asking is: does a course offering an initiation into research in mathematics education allow the students to enter a process of reflection upon their own practices, on the mathematical content taught in class and on their didactics, reflection which could promote their professional development as teachers? In this paper, we will focus on the tools that we are building to witness potential similarities between our former students' practices when they begin teaching in class, and link them to what was aimed for during the training.

Initiation into research in mathematics education, inside a teacher training program

The content of the course "initiation into research in mathematics education", in the Master's program for school teachers in the University of Créteil, is inspired by research results from the French field of *Didactique des Mathématiques*, and particularly results about the content taught in nursery and primary school (pupils aged 3 to 5 and 6 to 10 years old respectively), and about the related teaching and learning (and of course the content offered in this part of the training is influenced by the interests of the researchers participating as educators in this part of the training as well as in other courses). Our priorities are to prepare the students for their 50-page research report but also to bring them knowledge and tools that we consider useful and essential for their practice as future school teachers (for example, the ability to analyse and criticise a textbook on a mathematical topic, which is both a research and a teaching tool). The main theory that we talk about and use for analysis is the Theory of Didactical Situations (Brousseau, 1997), which can also be found among the objects and vocabulary used in other courses in the rest of the training, through some of its conceptual notions (such as *didactical contract* (a system of reciprocal obligation between the teacher and the students that sets their responsibilities, mainly implicitly, in class, during a didactical situation); *didactical variables* (parameters of the situation, with values that affect solution strategies. The effects can be of three kinds: (i) a change in the validity of a strategy, where a strategy that produces a correct answer with a certain value of a didactical variable will produce an incorrect answer with another value; (ii) a change in the cost of the strategy, for example, counting elements one by one is efficient for a small number but much more costly for a larger number; and (iii) the impossibility of using the strategy. (Mackrell et al., 2013); or, *devolution* ("the act by which the teacher makes the student accept the responsibility for an (adidactical) learning situation or for a problem, and accepts the consequences of this transfer of this responsibility" (Brousseau, 1997)) and *institutionalization* (which can take place after a series of activities where a piece of knowledge has been useful in the class to act on, communicate, or validate something, and is then linked by the teacher to a more general and shared knowledge)). Some of the sessions deal with particular mathematical content, its learning (pupils' errors) and its teaching (didactical strategies). Other sessions are more focused on the work with tools for the researcher, depending on the data to be analysed (textbooks, pupils' papers, videotaped sessions) or around the research literature (database, critical review). There are also many sessions dedicated to helping the student teachers with their research report.

Theoretical frameworks: Many levels of analysis

When trying to build some tools to try to assess the effects of the training on professional development, we have to be able first to analyse every stage of the training process, from the analysis of our goals and choices as teacher educators, to the analysis of the practices and choices of the teachers that we trained, during the first two years of their teaching when we

are in their classes. This is a complex process, with many sides and points of view (the researcher's, the teacher educator's, the student's, the teacher's), and with many pieces of knowledge (on mathematics, on pupils, on teachers) (Shulman, 1986, although note that we do not use this framework in this research because we do not use the same categorisation of knowledge), some transmitted through the training, and some only influencing our choices without being visible to the students.

Different frameworks are thought to be useful for this study at different levels: to guide our choices for teacher training; to implement this training; and to analyse both its setting and its effects on students. We propose a multi-dimensional approach.

The Theory of Didactical Situations (Brousseau, 1997) is useful to us when we analyse sessions in class, in terms of *didactical variables* and *a priori analysis* of a task or situation. These are among the tools that we are presenting to our students during the initiation into research in mathematics education. They can be used to build and/or analyse situations for the classroom, to teach or to experiment in class with a research question. We also use the concepts of *chronogenesis* (progress of didactic time: description of the evolution of the knowledge proposed by the teacher and studied by the students) and *topogenesis* (change of positions of students and teacher with regard to knowledge (cf., for example, Laborde & Perrin Glorian, 2006).

To analyse and interpret teachers' practices, as well as our own as educators, we use the Theory of the Double Approach (Robert & Rogalski, 2005) defining five components in teachers' practices: cognitive and mediative components (what happens in class in terms of content and teaching/training strategies), but also personal, institutional and social (the curricula, the background, the institution, the colleagues ...). This theory allows us to take into account some constraints, which can explain teaching and training choices (for example, the fact that the content that we teach is linked to our own research can be explained through the personal component of our practice as educators).

Our hypotheses about teacher training also come from the Double Approach: being willing to take into account the constraints of training (not everything is possible for any teacher on any classroom) and the actual practices and needs of the teachers while training them. Regularity observed among teachers' practices might then be linked to their training, and variability of their practices linked to the particular constraints of the profession applied to each teacher.

To refine our analysis of teachers' practices, we use the concept of *didactical vigilance* (Charles-Pézard, 2010): we consider the permanent didactical adjustment made by the teacher in class and outside of class at different levels (local, global, micro practices), mobilising knowledge on mathematics as well as the way they are taught to analyse situations *a priori* and *a posteriori*, using tools from the Theory of Didactical Situations to detect phenomena in the classroom and take decisions regarding them.

To take into account the complexity of the teaching practices, we need to develop a multi-dimensional study, intertwining several frameworks, depending on what we focus on (teachers' or educators' practices), with a more or less wide focus.

METHODOLOGY

Based upon the rich theoretical material that we presented in the previous section, we built several grids of analysis to link the teachers' training and the teachers' practices potentially achieved through training (and later compared to the practice that we actually observed in class):

- a list of the types of tasks actually proposed during the training through the initiation into research in mathematics education;
- a list *a priori* of the expected teachers' practices that could be shaped by the work done during the training, the ones we might expect, based on research results of practices and on the national list of competences for teachers;
- a scale *a priori* of professional development of the school teachers, linked with the activities of the teachers in class.

We will show these grids and how we put them into use to assess and interpret teachers' professional development linked with their training.

The list of the categories of tasks that we proposed during the initiation into research in mathematics education

We analysed the content of the two-year course organised for the initiation into research in mathematics education in the Master's training program of the university of Créteil between 2011 and 2013. This content was not chosen with this research in mind, given that the research only started in 2013, two years after the beginning of the course. We considered the tasks given to the student teachers during the sessions and drew a list of types to characterise what our student teachers might have worked on: different kinds of analysis (mathematical tasks, pupils' productions, textbooks, mathematics sessions) as well as bibliographical work or the construction of the research questions and the methodology to test them. Some of these tasks can be found in the rest of the training but probably dealt with in a different way and with other aims: for example, mathematics sessions' analysis *a priori / a posteriori* are probably also proposed in the professional blocks of the program, but without a research question in mind. Tasks such as selecting, reading and analysing research articles might only be found in the research part of the training.

We consider that answering a research question and answering a professional (teacher) question does not require the same tools and resources. The data analysed might be the same (pupils' productions, textbooks) but with a different question in mind (testing research hypothesis). We believe that the resources used for the initiation into research are different from the ones the student encounters in the rest of the training (research articles / institutional documents). We also think that doing an experiment in class and teaching are not the same activities, even if they both usually involve building and implementing a session. The analyses involved are not the same and will not produce the same effects in the classroom.

The list of expected teachers' practices

The list of expected practices of the teachers when teaching mathematics was drawn up *a priori*, not considering what might or might not have been addressed during the training, but using the French reference of competences for teachers and some results in mathematics education research on teachers' practices that have been linked to potential learning for the pupils in mathematics. This helped us focus on particular activities of the teachers when they teach, or prepare their class, taking into account the mathematical content aimed at by the teaching:

- Choose or build a pertinent situation regarding the learning goals and the progression in learning;
- Know the mathematical content to be taught and their didactics;
- Manage different types of sessions (introduction, institutionalization, training, assessment, ...) and the different moments of a session (devolution, research, comparison of the procedures, validation, ...);
- Evaluate the pupils' learning and manage their heterogeneity;
- Reflect on one's own session afterwards, keep training and innovating.

We can see, in particular, considering the types of tasks proposed during the initiation, which practices we did not train at all (build an entire sequence of sessions on a subject for example) and the ones on which we spent much time (analysing tasks and sessions in class), but of course we cannot isolate the particular effects of the initiation into the global training.

The levels of achievement for every teacher activity

To analyse the evolution of every teacher's practices and compare it with other teachers, we built three levels of achievement for the practices (see Table 1). It takes into account what happens in the classroom, in terms of tasks and management, as in Butlen *et al.*, (2011), but also, on a more global focus, the preparation of the class by the teacher, and the reflection that he or she can have upon his or her own sessions. To illustrate this scale, we give an example, to assess the competence of a teacher for "managing different moments in a session" (see Table 1): level A is the highest one, and includes elements of analysis from the Theory of the Didactical Situations, to characterize the different phases of the session (from the *devolution* to the *institutionalization*).

Level C	Level B	Level A
*The different moments are not clearly identified (collective + individual research, no comparing of the procedures) *Not many initiatives for the pupils, the teacher is in charge of the validation *No moment of recollection of previous knowledge	*Some moments are organized during the session but they do not allow the pupils to engage actively in research or to compare procedures *Shared initiatives but the teacher is still in charge of the validation *The moments of recollection are about tasks and not knowledge, and taken in charge by the teacher	*The "launching" of the activity is organized (re-wording) *There is potential for active research for pupils *Procedures are gathered and compared with a hierarchy in the order in which they are presented, with shared initiatives for their validation, and construction of mathematical meaning *a summarization is made, leading to an institutionalization (*dépersonnalisation*, *décontextualisation*) linking it with the previous activity *Some moments of recollection of previous knowledge are promoted by the teacher

Table 1: An example of the three levels of achievements of teacher activity (managing different moments in a session)

EXPERIMENT AND FIRST RESULTS

To analyse the practices of our former student teacher with as much objectivity as we could, we built the categorization of the teacher practices and defined three levels of achievement for each of them, based upon some *a priori* result from mathematics education, and from national standards. We confronted these grids with the actual practices of our students, once they had started teaching full time in school, after the end of their initial training.

Data collected

We followed 13 students out of the 16 who took part in the initiation into research in Mathematics Education course between 2011 and 2012, who agreed to participate in the study, in order to assess the effect of their training:

— 7 out of 13 answered a questionnaire at the end of their Master's program, about their opinion of their training, with questions on their background before the training, but also on the interest they had taken in each of the subjects proposed in the initiation into research course, and the use they made (or thought they could make in the future) of the content of their training for their teaching.

The answers of our students to the questionnaire filled in at the end of the training showed a certain lack of interest for the theoretical content of the research initiation. The reasons why they chose our initiation into research in the first place vary from: "good in math" to "fear of teaching math", which means that we do not only have the best scientific students in our study. We asked them also to point out links between the research initiation course and the rest of the training, and they did not seem to see much common ground between research and the professional part of the training, not even with the same tasks proposed in both cases. We still have to pursue this study, but the small number of answers does not allow us to draw on the results of this questionnaire much.

— We followed our 13 former students (the ones who volunteered out of the 16) through observations in class and individual interviews by one of the researchers, during their first years as teachers.

We did not record the sessions (as it would have been difficult in this context) but the researcher who did the observation filled in a grid that we all had built before the observations, about the context of the school and the class, the phases organized by the teacher and the mathematical content and tasks proposed during the session, according to the tools we have set in place to analyse teachers' practices in mathematics. The interview allowed us to know if the teacher explicitly used some tools from the research training (through his or her vocabulary for example, or when describing his or her activity with other words than the ones used with us during the training), and to ask questions about how they would describe now the contribution of the training to their practices.

We also followed in class 8 student teachers who did not choose our initiation into mathematics education (but followed an initiation into research in another field). This part of the data has been collected but not analysed yet. It should allow us to pinpoint specificities of our former students, but we will not have as

Expected practices	C	B	A
Choose or build a pertinent situation regarding the learning goals and the progression in learning	1	5	6
Choose a textbook or other resources and use them with a critical view	1	6	5
Know the mathematical content to be taught and their didactics	1	8	3
Manage different types of sessions	1	8	3
Manage the different moments of a session	1	9	2
Evaluate pupils' learning	1	7	4
Manage the heterogeneity of the pupils	1	4	7
Reflect on one's own session afterwards	1	8	3
Keep training and innovating	1	9	2

Table 2: Levels of achievement of our former students at the end of their 1st year in class

much information on these eight students' training, which will be an important limitation.

First results in class

Trainers have to visit teachers twice in their classroom during their first year after training, to assess their work, and the two observations took place in this context. The evidence assessing the level of achievement for each element of the practices comes from the two observations, a few months apart, of half a day of class, including, each time, a session in mathematics, and from the interview that took place at the end of the second visit. The results for our 13 former students can be seen in Table 2.

We can see here that the global level of achievement of the 13 beginner teachers is between B and A, except for one student (who obtained a level C for each activity; it was a student who was in great difficulty, and did not succeed in becoming a teacher at the end of her first year in class). They built rather meaningful and pertinent situations for their class in mathematics, with an *a priori* analysis that allowed them to anticipate the pupils' difficulties in most cases.

They seem particularly efficient in managing the different phases of the session, with long phases of research for the pupils in certain classes. This is a type of task that has been often proposed to the student during the initiation into research course, while analysing videos, or experimenting in class for the research report. Validation of the tasks is still performed by the teacher rather than letting the pupils take the initiative.

Their opinion on the content of their training through the initiation into research has often evolved (from "too much work, too much theory" to "useful for preparing the session and reflecting on it afterwards"). Though they do not use concepts from the didactical theories in their discourse, they still seem to enact them in their practice (*didactical variables*, comparison and *organisation of a hierarchy in the* pupils' procedures, *a priori* analysis). For example, even if almost none of them used the term "*a priori* analysis" during the interview afterwards, they showed some capacity to analyse the content of their sessions, and the potential gaps between what was planned and what actually happened during the session. Incidentally, in the questionnaire at the end of the training, the majority of the students said that some content of the initiation was helpful to anticipate pupils' procedures, and that some of the content also gave them means to analyse their own sessions afterwards.

They seemed to us very reactive when reflecting on their sessions (changing things from their original plan immediately to take into account our remarks) and giving themselves means to keep improving their practices; which could confirm our hypotheses about the value of training through research to help the teacher enter a reflexive attitude for their teaching. Of course we still have to analyse the data collected in the other classes to confirm these results.

CONCLUSION

Even if the first results on teachers' practices during their first year teaching are very encouraging to us, we obviously have to underline the many limitations of our research:

— the small number of students, that does not allow us to generalise our findings;

— the impossibility to totally differentiate the effects of the research training from the effects of the rest of the program (but the questionnaire gave us an idea about the originality of the tasks proposed in our initiation, compared to the rest of the training, in which we also take part);

— conflicting roles of researchers, at the same time teacher educators and evaluators of the students whose practices they are trying to assess (even if we tried to separate the research from the assessment by giving clear protocols to the students) in a training context that was not built as an experiment on teachers' development.

As teacher educators, this study helped us build tools to organize the training, and gave us a clearer view of what we can potentially offer to the prospective primary school teachers through an initiation into research. We already made changes in our initiation program to take into account the needs of our students and address the question of the development of their practices more efficiently.

But we still have a lot of research to do to assess the real effects of training in general and through research in particular.

REFERENCES

Brousseau, G. (1997) Chapter 1. In N. Balacheff, M. Cooper, R. Sutherland, & V. Warfield (Eds.), *Theory of Didactical Situations in Mathematics* (pp. 21–76). Dordrecht, The Netherlands: Kluwer.

Butlen, B., Charles-Pézard, M., & Masselot, P. (2011). Deux dimensions de l'activité du professeur des écoles exerçant dans des classes de milieux défavorisés : installer la paix scolaire, exercer une vigilance didactique. In *Actes du Colloque international INRP, 16, 17 et 18 mars 2011* « *Le travail enseignant au XXIe siècle Perspectives croisées : didactiques et didactique professionnelle* ».

Butlen, D., Masselot, P., & Pézard, M. (2003) De l'analyse des pratiques effectives de professeurs d'école débutants nommés en ZEP/ REP à des stratégies de formation. *Recherche et formation, 44*, 45–61.

Charles-Pézard, M. (2010) Installer la paix scolaire, exercer une vigilance didactique. *Recherches en Didactique des mathématiques, 30*(2), 197–261.

Grugeon-Allys, B. (2010) Evolution des pratiques des professeurs débutants de mathématiques pendant les premières années d'exercice. In R. Goigoux, L. Ria, & M. C. Toczek-Capelle (Eds.), *Les parcours de formation des enseignants débutants. Clermont-Ferrand, France:* Presses Universitaires Blaise Pascal.

Grugeon, B. (2008). Quelle évolution des pratiques d'un professeur stagiaire de mathématiques pendant son année de formation à l'IUFM. In F. Vanderbrouck (Ed.), *La classe de mathématiques : activité des élèves et pratiques des enseignants* (pp. 328–366). Toulouse, France: Octarès.

Laborde, C., & Perrin-Glorian, M. J. (2005). *Introduction. Special issue "Teaching situations as object of research: Empirical studies within theoretical perspectives"* (edited by C. Laborde & M. J. Perrin-Glorian) of Educational Studies in Mathematics, 59 (1–3), 1–12.

Mackrell, K., Maschietto, M., & Soury-Lavergne, S. (2013). Theory of didactical situations and instrumental genesis for the design of a CabriElem book. In B. Ubuz, Ç. Haser, & M. A. Mariotti (Eds.), *Proceedings of CERME8* (pp. 2654–2663). Ankara, Turkey: Middle East Technical University and ERME.

Robert, A., & Rogalski, J. (2005). A cross-analysis of the mathematics teacher's activity. An example in a French 10th-grade class. In C. Laborde, M.-J. Perrin-Glorian, & A. Sierpinska (Eds.), *Beyond the Apparent Banality of the Mathematics Classroom* (pp. 269–298). New York, NY: Springer US.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.