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Large scale analysis of teachers' assessment practices in mathematics

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In this paper, we present a questionnaire that we have designed to establish a picture of secondary school teaching assessment practices in mathematics. This research follows a request from the Ministry of National Education, to take into account a specific mathematical content (algebra) in the analysis of teachers' practices at a large scale (1200 teachers). We begin by presenting our theoretical and methodological tools to characterize teacher assessment practices, and then present the project and the methodology adopted to link teachers' practices and their students' learning. We then give some examples of questions that we have designed for the teachers' survey, to be implemented in the fall of 2018.

Keywords: Assessment, teachers' practices, algebra, national surveys, teacher survey.

General presentation of the project

The DEPP (Directorate for Evaluation, Prospective and Performance) is responsible for the design, management and operation of the statistical information about the education system in France. It contributes to the evaluation of policies conducted by the Ministry of National Education. It has already developed an expertise about assessment, through national and international surveys on education, which focuses mainly on generic teaching conditions and practices, and not on practices related to a specific content. At the same time, the DEPP periodically assesses 5th graders (last year of elementary school) and 9th graders (last year of middle school) in the curriculum's disciplines by the CEDRE test (Cycle of Disciplinary Evaluations carried out on a Sample basis).

The new cycle of student's assessment which began in June 2018 is the first opportunity to establish a picture of teaching practices on a specific mathematical content. In this context, the goals of the PRAESCO 2017-2019 programme (Enquiry on Teaching Practices based on Specific Contents) are to make available to policy-makers and the educational community a set of indicators on teaching practices in mathematics, and to research the effects of these practises on the students' learning of specific mathematical contents (numbers and calculation for the 5th graders and algebra for the 9th graders). The role of the researchers commissioned by the DEPP is to build a questionnaire based upon a theoretical framework for identifying variables in mathematics teaching modalities, and to bring a scientific and didactic dimension to the analysis of this survey. In this paper, we focus on the design of the survey about teachers' assessment practices at the 9th grade level. Our theoretical and methodological frameworks

We explain our theoretical framework for the analysis of teachers' practices and more particularly for assessment practices in relation to students' learning in mathematics. We also explain our choice to select algebra as the specific mathematical content for the survey.

Teachers' practices and students' learning in mathematics

Our hypotheses on teaching and learning are based on the adaptation of the Activity Theory for didactic (Vandebrouck, 2018): it is mainly through students' mathematical activities that their learning takes place, activities caused, in large part, by the tasks they are given to do. The tasks therefore have a central place in our analyses, to anticipate possible learning for the students, but also to characterize teachers' practices through their choice of tasks for the students and the actual implementation of the work around those tasks in class.

To have a more comprehensive view of teachers' practice, we adopt the theoretical framework of the Double Approach (Robert & Rogalski, 2005), taking also into account some determinants of teacher practices that are not only related to the targeted students' learning. We consider the various constraints that influence the teaching profession, which leads us to include in our analysis of teachers' practises, institutional, social and personal components of the teaching profession, in addition to cognitive and mediative ones.

In this large panorama of teachers' professional activities and context, we consider that assessing students plays a significant role in the teaching and learning process, as it allows the students' actual mathematical activities to be taken into consideration by the teacher, to build appropriate teaching, in the short or long term. This is why our questionnaire includes a section about assessment practices, that we will describe below.

Assessment

In our previous work (Horoks et al., accepted; Pilet & Horoks, 2017), we have built a framework for analysing the assessment practices of secondary school teachers in mathematics, considering the specificities of the mathematical content. The various definitions of *assessment*, found in the literature and on which we rely, highlight three dimensions in the act of evaluation: taking information, interpreting it and using it for decision-making. We characterise *assessment practices*, using De Ketele's (2010) definition, through everything the teacher does to take information about students' mathematical activities (what they do, know, say, write) and how the teachers use this information, especially to promote students' learning. For De Ketele (*ibid.*), this information must be sufficiently relevant, valid and reliable, leading the teacher to examine its degree of adequacy with a set of criteria, linked to the teacher's goals, to make a decision. For Black & Wiliam (1998) also:

The term 'assessment' refers to all those activities undertaken by teachers, and by their students in assessing themselves, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged. (Black & Wiliam, 1998, pp.7-8)

Depending on the function given to assessment by the teacher, this collection and exploitation of information can be done in different ways, more or less formal and with greater or lesser effects on teachers' subsequent choices for their class.

For Black & Wiliam (1998), students' assessment is called *formative* when the information collected by the teacher is used to meet students' needs and when the students can self-evaluate through the realization of the tasks that they have been given. Ash & Levitt (2003) argue that

formative assessment is a joint teacher-student activity, which remains fairly close to what the student already knows how to do. The teacher collects clues about one student's activity in order to analyse this activity and plan the next step to help this student evolve.

Algebra

In this project, our approach to analyse teachers' practice, focuses on the mathematical contents to be taught, which led us to choose the field of elementary algebra, by consensus among the participants of the project, and for several reasons. First of all, because elementary algebra represents an important challenge for the future of students' studies in secondary and higher education, but also because teachers often express difficulties in teaching algebra (Kieran, 2007). It is also a choice that allows us to build on existing research results in mathematics education about the teaching of algebra. We have relied on the work of (Grugeon et al., 2012; Pilet, 2015; Sirejacob, 2017) who, on the basis of an epistemological study, have established a reference for a *mathematical organization* (Chevallard, 1999) of the teaching of algebra at this school level. The latter provides the types of tasks representative of the algebraic domain, which makes it possible to question the coverage of this domain by the tasks proposed by teachers, and the pertinence of these tasks (for learning or for assessment). This reference also provides information on the levels of reasoning expected from the students, and on the properties that can be brought forward by the teacher to institutionalize knowledge, validate or invalidate students' productions.

Presentation of the methodology

General protocol

Our framework to analyse assessment practices has already been used for studies involving fewer teachers, but over a longer period (several years). The transition to a larger scale requires a specific methodology, that we have been designing with the DEPP during the first year of the project. The general protocol is presented in Table 1. This study is based on statistical and didactical analyses performed by the researchers.

Period of time	Protocol
January – September 2018	Design of the questionnaire
September - November 2018	Selection of teachers for the first version of the questionnaire
December 2018	Experiment (teacher's first version of the questionnaire and assessment of the students' algebraic skills)
January-February 2019	Analysis of the experimental data and classroom observation for a sample of 50 teachers, improvement of the questionnaire
April – May 2019	Selection of teachers for the final version of the questionnaire, with a sample of 1200 secondary mathematics teachers
June 2019	Implementation of the final version of the questionnaire
June 2019 – February 2020	Analysis of the data

Table 1: General protocol

In an attempt to overcome the fact that a questionnaire can only give access to declarative practices, we chose to complete the analyses by observing some teachers in their classes. For that purpose, the first experiment, to be carried out from December 2018, involves only 50 teachers, chosen as a representative sample of teachers in France among the 1200 teachers (in terms of experience, teaching environment and geographical context) selected for the first version of the questionnaire.

These teachers will also fill the questionnaire while their students are assessed through a mathematical test. Later on, they will be observed while teaching algebra in their classroom (on the cognitive and mediative components of their practises, as defined by the Double Approach (Robert & Rogalski, 2005) and also asked questions about their work outside of class. This first step is smaller by the number of teachers involved, but more demanding for the researchers, because of the observation accompanying the questionnaire. It should help us identify whether the questions of the questionnaire are reliable and relevant for characterising teachers' actual practices through their answer to the questionnaire and improve the final version of the questionnaire that will be proposed at a larger scale in June 2019.

In the same perspective, we ask the teachers, in the beginning of the questionnaire, to choose one of their 9th grade classes, and to answer the questions with this particular class in mind. We believe that the identification of a reference class and the choice of a precise mathematical content allow us to get as close as possible to the real practices of the teacher. In addition, an assessment of the students in the teachers' reference class is conducted (around 30 000 students in total), in order to investigate a crucial issue: the impact of practices, and more specifically teacher assessment practices, on their students' learning.

Designing the questionnaire

To design the questionnaire, we brought together a team of researchers in mathematics education and experienced mathematics teachers in secondary education. Regular meetings, some of which were held with the members of the DEPP involved in the project, allowed us to agree on the formulations for the questions, in order to be able to perform a valid analysis of the teachers' answers, both from a statistical and didactical point of view. The questionnaire was then tested on teachers, whom we contacted individually, to ensure that the questions were understood and to have a better idea of the time required to complete the questionnaire, which final online version should not exceed 45 minutes for the teachers to answer.

The questionnaire consists of 121 questions (530 sub-questions in total). For statistical analysis purposes, the questions are closed-questions with multiple choices, with 4 level - scales (of frequency, difficulty, opinion, or adequacy to content or to students). Some of the questions focus specifically on algebraic contents, others focus more broadly on practices when teaching mathematics in general. To support possible results, we sometimes question the same aspect of practices in several questions but with different formulations throughout the questionnaire.

The questionnaire consists of 4 sections, with questions about:

- the teaching context and the teacher's background (experience, training, institutional constraints and possibilities, uses of technology for teaching and personal views on teaching and learning, especially about algebra)
- classroom preparation (resources, selection of algebraic tasks, time allotted to specific contents and tasks)
- management of classroom teaching (classroom work arrangements in the different phases of a mathematics session, interactions in class)

- and student's assessment (20 questions, 106 sub-questions, including 31 sub-questions about algebra).

In this presentation of the 9th grade level survey, we are focusing on teaching practices in elementary algebra, and in particular the practices of the teachers to assess their students' learning on this content. We make the hypothesis that assessment can play a rather important part in students' learning, but of course it is not easy to separate these particular practices, and their effects on students, from the rest of teachers' actions.

Questions about the assessment practices

In the last section of the questionnaire, we ask questions about teacher's relationship with assessment as well as the way he or she implements assessment in class. Concerning the teachers' relationship to assessment, we want to characterize in particular the functions given to assessment by teachers, including or not a better learning for their students (grade, rank, distribute, sanction, etc. Merle, 2015). In terms of teachers' assessment practices, we have applied the definition of assessment - *taking information, interpreting it and using it for decision-making* - to design this part of the questionnaire.

We want to identify the moments (Chevallard, 1999), where teachers gather information on their students' knowledge (before beginning to teach algebra in their reference class, or at the end of this chapter, and throughout the teaching of this subject), and the means used to do so, through formal or informal processes (Allal & Mottier-Lopez, 2007) and through which type of algebraic task, made more or less obvious for the students by the teachers' discourse.

We also try to appreciate the way teachers interpret some information about their students' possible answers to given tasks, by asking them to comment on student's productions (cf. Figure 1, with a question concerning also the decision making based on this interpretation). It might also give us access to the teachers' relationship to algebra, and the role of error in their vision of mathematics teaching, as well as their consideration of the students' procedures rather than their only results.

Here is the text of a summative assessment task and Guillaume's production:

Here is a calculation program:
 Choose a number, Add 7, Multiply the result by 4, Subtract 3 to the last result
 What is the result of this program if at the beginning the chosen number is 6?
Guillaume's answer: $6+7=13 \times 4=52-3=49$

When I assess Guillaume's production, I consider that:

	I disagree	I rather disagree	I rather agree	I agree
The result is correct, and I won't give Guillaume any feedback on the calculation, as he will understand later why it is not correct				
The answer is correct, but I will write a comment to explain that it is not correctly written mathematically				
If a lot of students have written the calculation this way, I will take a moment to clarify it with the entire class				
The result is false, because the way it is written is not correct				

Figure 1 – Example of a question about the judgment on a student’s production in a summative test

We also question the teachers about the exploitation they usually do, of the information about their students’ knowledge or know-how: if and how they adapt their teaching consequently, for some students or the entire class, and with which support on the mathematical contents.

In fact, several questions about assessment practices appear in other sections of the questionnaire. In the first part, about the context and personal information, we ask teachers if they feel the need for further training about students’ assessment, among other topics. We also ask them about the possible origins for their students’ difficulties in mathematics, and their students’ needs to understand what is at stake in algebra, which can be linked to diagnostic assessment. The choice of tasks that they make for their *reference class*, largely questioned in the third part of the questionnaire, focusing on teachers’ preparation of the class, can also be compared with the tasks chosen for assessment, to spot possible gaps between the two.

In the questionnaire’s part about the management of the teaching in the classroom there are questions about the collective work on students’ productions on a given task, that we link to assessment. Some questions in this part also (see Figure 2) focus on students’ error management and ask the teachers to position themselves on the levels of mathematical discourse they generally use with their students (from almost never to very often). The following proposals (figure 2) participate, more or less, to a process of *formative assessment*. For example, Proposal 4 (figure) doesn’t rely on the mathematical properties linked to the preservation of equality, but is referring to the gestures accompanying the technique, which we do not believe to be rich enough to help the students understand their mistakes and learn from them (Sirejacob, 2017).

In my class, when solving the equation $8x+5 = 3x+20$, a student writes:
 $8x-3x=20-5$ so $5x=15$ so $x=10$

Here are different proposals for the teacher to address the error made by this student. Give your opinion on each of these proposals:

- 1) *The teacher asks the student to recognise the operation between 5 and x, and draws the student’s attention on the difference between addition and multiplication.*
- 2) *The teacher asks the student to replace x by 10 to see if 10 is a solution of the equation.*
- 3) *The teacher asks the student to look up in his or her textbook to find the mathematical property to be used here*
- 4) *The teacher asks the student to tell how the 5 can be passed on to the other side of the equation*

Figure 2 – Example of a question about the management of a student’s error in class

About the particular case of summative assessment, which is the kind of assessment that is the one most associated to the act of evaluation by teachers in France (De Ketele, 2010), the questionnaire asks about its frequency, duration and formats, with a particular interest for the teachers’ choice of tasks for that purpose. This choice reveals a potential link with the algebraic tasks chosen for this chapter in the *reference class*, in terms of domain coverage, pertinence for assessment or learning, and also, in terms of complexity and variety among all the possible tasks. The practices for correcting these summative assessments are also investigated (through the scoring, the feedback to students) as they allow us to better understand the function of these assessments and their potential formative dimension (see Figure 3).

After a summative test is taken in my class:

	Almost never	Sometimes	Often	Very often
I give the correction in class for every task in the test				
I give the correction in class only for some of the tasks				
I organise a moment for questions after the students have consulted their corrected paper				
I select some of the students' answers to be discussed collectively in class only for some of the tasks				
I return the students' corrected papers without spending any additional time on it				
I provide a version with the correct answers to the test				

Figure 3 - Example of a question about the feedback to the students after a summative test

Analysing the questionnaire

In order to analyse the teachers' answers to the questionnaire, computed by the DEPP after the implementation of the large-scale survey, and to link them to their students' results to the test in algebra, we rely on hypotheses about the possible impact of assessment practices on students' learning. We suppose that some choices might better promote learning: for example, organising a regular feedback for the students, as part of a formal or informal assessment, comparing different possible students' answers and highlighting the algebraic properties at work behind each procedure, to explicit and validate or invalidate the students' work. From these hypotheses, that will be challenged by the confrontation of the teachers' practices to their students' results, we define several teachers' profiles, including assessment practices in algebra, but also more widely, practices for the teaching of mathematics, in a given context.

This paper is focused today mainly on the design of this survey, as it displays a very ambitious methodology, and because we do not have results to show about this study at the moment. But we should be able to present already some preliminary findings at the time of the conference, about the next steps of the survey.

Conclusion

This project presents major challenges, since it is the first requested by the DEPP in France to focus on the diversity of teaching practices relating to specific disciplinary content, at a large scale. The survey is not a protocol for assessing a teacher's individual performance but aims to appreciate the diversity of teaching practices. The simultaneous test addressed to the students along with the teachers' questionnaire, might also allow us to link teaching practices and students' learning at a large scale.

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