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University teachers' resources and documentation work

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In this paper, I investigate university teachers' documentation work: their interactions with resources for preparing and delivering their teaching, and the consequences of these interactions. I have interviewed and collected the material resources used by six university teachers working in France. Analysing the data collected, I observe specific features of their documentation systems, concerning crucial resources, professional development, and the place of digital resources.

Keywords: Documentation systems, documentation
geneses, professional development, resources.

INTRODUCTION: STUDYING TEACHERS' WORK WITH RESOURCES AT UNIVERSITY

The work presented in this paper belongs to the growing field of research concerning university teachers' practice (e.g., Nardi, Jaworski, & Hegedus, 2005), with a specific feature: I consider the teacher's work in class, but also out-of-class. I investigate indeed university teachers' work with resources, with a documentation approach perspective (Gueudet, Pepin, & Trouche, 2012). Previous steps have been done at CERME8, with a study concerning the detailed case of one teacher, working in a technological institute (Gueudet, 2014). The theoretical aspects of such a study and the specific features from university concerning teachers' documentation work have been deepened in Gueudet, Buteau, Mesa and Misfeldt (2014), within the RME special issue concerning "Institutional, sociocultural and discursive approaches to research in university mathematics education".

I firstly briefly recall the main elements of the theoretical approach. Then I present the methods, organised around the cases of six teachers with different profiles. I present the results obtained by analysing interviews with these teachers and the material resources they

use, focusing on the documentation systems structure, on crucial resources, on professional development and on the place of technology.

THEORETICAL FRAME, CONTEXT AND METHODS

I retain in this work the theoretical frame provided by the documentational approach of didactics (Gueudet et al., 2012). According to this approach, teachers interact in their work with a variety of *resources*. The concept of resource is considered here with the meaning introduced by Adler (2000): a resource can be a textbook, but also a symbol, or more generally anything likely to re-source the teacher's professional activity. Teachers look for resources, sometimes they meet resources that they were not looking for (discussing with a colleague around the coffee machine, for example). They associate these resources, modify them, conceive their own resources and use them with students. All this activity is called *the documentation work* of the teacher (Gueudet et al., 2012). During this documentation work, interactions take place between the teacher and the resources; and these interactions contribute to teachers' professional development. Drawing on the instrumental approach (Rabardel, 2002/1995; Guin, Ruthven, & Trouche, 2005), the documentational approach considers that teachers are involved with sets of resources in a goal-oriented activity. Along this activity and for a given goal, they develop a *document*: the association of resources and of a scheme of use (Vergnaud, 1998) of these resources. Schemes of use encompass three ingredients: the objective of the activity; rules of action (a usual way to act for this objective); operational invariants, which are here professional beliefs. This process (development of a document) is called a *documentational genesis*. Multiple documentational geneses occur along the teacher's work for various goals; they contribute to produce the *documentation system* of the teacher,

which is the structured set of all the documents he/she develops. With this perspective and concepts, the central research questions that I address in this paper are:

What is the content and structure of university teachers' documentation systems? Which are the evolutions of these systems, and how are these evolutions linked with teachers' professional development?

In Gueudet and colleagues (2014), I have discussed possible specific features of teachers' documentation work, in the context of university. One such feature is the possible central role of the work with resources for teachers' professional development, since in many countries teacher education is limited at university. Such a role has already been identified in the case of textbooks by Mesa & Griffiths (2012), using an instrumental approach: they have identified different schemes of use, shaping the teachers' practice. Moreover, many digital resources are available for university; and the online platforms permit to develop distant work with students. Are these digital resources present in the teachers' documentation systems, where do they intervene? In Gueudet (2014), I have investigated the case of a single teacher, who taught in a technological institute and was not involved in research. He used many technological resources, but he worked in a specific context. The place of technology in the documentation systems of university teachers in more "ordinary" contexts still has to be investigated.

I retain these foci, for the results I present here: the link between documentation systems and professional development, in particular the intervention of research in the development of documents and the place of technology in university teachers' documentation systems.

In this article, I study the cases of six colleagues, all of them working in France in the same middle-size university. These colleagues have been chosen to rep-

resent a variety of conditions that can influence their documentation work: experience, research domain, studies in France or abroad, position, gender. Table 1 below summarizes the six cases, according to these factors.

They also teach in a variety of "teaching units", concerning calculus, linear algebra, number theory, probability, numerical analysis in the first or second year of university. A teaching unit lasts 12 weeks and can comprise between four and six hours a week, with generally half of the time for the lectures and half of the time for tutorials. Most of these teaching units concern the "Mathematics, Computer Science, Economy, Electronics" degree (MIEE; 270 students in first year, amongst them 60 specialized in mathematics). Some of these teaching units concern all the MIEE students; some concern only one or two options, i.e. "economy and computer science". Most lectures are given in an amphitheatre for a maximum of 150 students. In fact for most teaching units, there is a single amphitheatre, with two exceptions: the first year calculus teaching is organized in small groups, like secondary school classes and in the first year linear algebra teaching, two lecturers work in parallel in different amphitheatres.

I met each of these colleagues for an individual interview (see the interview guidelines in the appendix) and collected all the resources they mentioned. The interviews were recorded and transcribed. I noted in each interview the kind of activities mentioned by the teacher, the resources cited, how many times each of them is cited, and in connection with which activity(ies). I also noted the collective work (with who, for which objective), the beliefs expressed about mathematics or about teaching issues. I then connected teachers' declarations and the content of the resources he/she uses or designs. For space limitation reasons I cannot present here a detailed analysis of each case,

	<i>Experience</i>	<i>Country of the studies, position</i>	<i>Research domain</i>
Bob (M)	7 years	France, lecturer	Numerical analysis
Doris (F)	17 years	France, lecturer	Symbolic computation
Nadia (F)	24 years	Italy, lecturer	Partial differential equations
Bill (M)	13 years	Germany and UK, lecturer	Geometric theory of groups
Mary (F)	2 years	France, PhD student	Geometric theory of groups
John (M)	1 year	France, PhD student	Spectral theory

Table 1: Profiles of the university teachers interviewed

I only present the main results from the whole group of participants.

RESULTS

General structure of documentation systems for teaching

Documentation systems are individual constructs. A detailed investigation of these systems, for each teacher participated, reveals specific features. Nevertheless here one of my aims is to identify common aspects in the structure and content of these systems. Naturally, a first general description leads to identify two potential systems: one for teaching and one for research. I did not ask the teachers about their resources and documents in the context of their research activity. I focus here only on the documentation system for teaching – but I try at the same time to identify in it documents which can also belong to the documentation system for research.

“Teaching” here refers to a large range of activities, with different aims: preparing a lecture, giving a tutorial, correcting worksheets, answering students’ e-mails, etc.

So the documentation system for teaching is itself composed of different subsystems. For the teachers I interviewed and the teaching units concerned, except in special systems which I discuss later, the documentation systems for teaching comprise four subsystems, linked to different activities: (preparing and giving) lectures; tutorials; assessments; and communication.

Starting from this general structure, I first try to identify crucial resources, defined as those that are present in the intersection of several subsystems. These resources intervene in documents for different aims of the activity. As a consequence, their features are linked with schemes and thus beliefs concerning

mathematics and their teaching which have an important influence on the teacher’s practice.

The analysis of the interviews indicates that three kinds of resources appear as crucial: the “polycopie”; the exercises sheets; and the texts of previous exams.

THE CRUCIAL RESOURCES AND CORRESPONDING DOCUMENTS

The “polycopie”

The polycopie is a text, corresponding more or less to the content of the lecture, which is available for the students on the lecturer’s webpage as a pdf file, from the beginning of the teaching. Teachers and students at university in France do not use textbooks. This polycopie is used by the lecturer, for the preparation of his/her lecture and by the teachers offering the tutorial, to be informed about the content of the lecture and prepare the tutorial. It also intervenes in the communication between teachers and between teachers and students but not in the preparation of the assessments. The documents developed from the resource polycopie are not the same, when the aim is to prepare a lecture, or to prepare a tutorial. The documents associate indeed resources and schemes. The schemes can incorporate the same beliefs (e.g. “When a usual function is a bijection on a given interval, its reciprocal is also a usual function whose properties must be learned”), with different objectives and rules of action. More importantly, the teachers have different beliefs concerning directly the content and the role of the polycopie. Some of them (Bob, Bill, John) think that students need to have access to the precise text that has been written on the blackboard (the most usual practice in this university, only one colleague amongst the six I interviewed used projects slides). The content of the polycopie should correspond to this content: if a student took incorrect notes, or missed a course, this is not a problem since the polycopie contains the reference text. Others (Doris, Nadia) think that the polycopie must only be a summary of the course, containing the most important results (“for theorems I do not write the proof on the poly”, Doris): the students’ notes are the reference text for their learning of the course. And one of the teachers I interviewed, Mary, thinks that the polycopie must complement the course by giving additional details, examples, worked exercises (“students must find additional information in the poly”), in particular for high-achieving students. As a result, from one

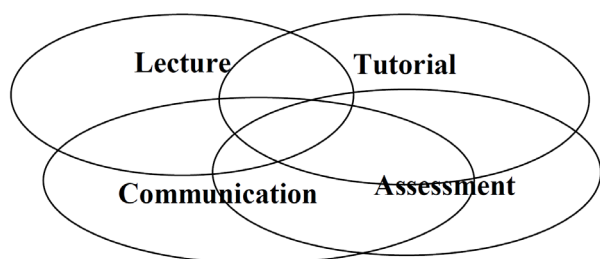


Figure 1: General structure of the documentation systems for teaching

teaching unit to another, the content of the polycopie can be linked to the content of the lecture in different manners.

The exercises list and the previous assessments texts

The exercises lists and previous assessment texts are crucial resources, both for the tutorials and the assessments (and they naturally also intervene in communication). Similarly to the polycopie, the exercises list and the previous assessments texts are given to the students from the beginning of the year, available on the lecturer's webpage. For most teaching units, the exercises list exists for a long time, amongst the teachers I interviewed, only two of them have been involved in the design of such a list. Nevertheless, the teachers develop from this list different documents. For the same objective, these documents encompass different rules of action, linked with different beliefs.

Nadia: Each year the first thing to do is to investigate who your students are, and adapt the content and expectations to these students (*rule of action*).

Nadia believes that, for the first year students who have a limited mathematical background, it is not necessary to ask for proofs in the tutorials.

Mary: I always start the tutorial by a summary of the content of the polycopie (*rule of action*), because they do not learn the course before the tutorial, some of them even do not attend the course (*operational invariant*).

Some of these beliefs, present in the documents developed for the tutorial, are linked with the teacher's research activity:

Nadia: Those who can say – well, I do not know this problem, but I will try to do something with my hands – this is a very important attitude for research.

The preparation of the exam and intermediate assessments texts is always a collective work. It can be shared in the group of teachers for a given teaching unit (in each teaching unit the students take between 2 and 6 exams and intermediate assessments), or proposed by the lecturer(s). This particular documen-

tation work: "writing an assessment text" has been studied by Lebaud (2009). The data confirm the results of the study by Lebaud. The document developed by the six teachers comprises the list of exercises, the previous assessments texts, and beliefs as: "the exercises for the assessment must be similar to those done in the tutorials"; "the assessment must cover all the content of the course". Participating in this collective documentation work contributes to the development by novice teachers of beliefs shared with their colleagues. This issue can be further studied in terms of communities of practice (CoP, Wenger 1998): novice students progressively become member of the CoP of mathematics lecturers, by sharing the same resources and practice.

Professional development and development of the documentation system

The university where the study takes place provides no professional development for the teachers. The progressive integration of novice teachers is managed by giving them gradually increasing responsibilities in the teaching, which I interpret here as: the professional development for teaching of novice university teachers corresponds to a development of the documentation system.

The PhD students I interviewed (similarly to all PhD students in this university) only offer tutorials. This means that they are given the polycopie, the exercises list and previous assessment texts at the beginning of the year. Their responsibility is to choose exercises from the list to work with their students during the tutorial. They could naturally choose other exercises, for the tutorial or for homework, but they do not do it, because the list of exercises is sufficient. Their first opportunity to design themselves exercises is provided by the writing of assessment texts, with other colleagues, as described above. So the professional development corresponds to the development of the documentation system: from a documentation system reduced to the subsystems for tutorials, assessment and communication to a documentation system incorporating also the subsystem for lectures.

In the case of a new lecture, the colleagues declare that they use books. In some cases these books are mathematics books addressed to higher level students: about numerical analysis (Bob), or symbolic computation (Doris), for example. The teacher then makes an important didactical transposition work

Lecture <i>Polycopie + Books (from higher level, or other countries). Sometimes: lecture notes of a colleague.</i> <i>Discussions with students at the end of lectures, evaluation of the teaching unit by students</i>	Communication e-mails sent by students, by colleagues website of the university, of the mathematics department <i>For a lecturer: Uploading files on his/her webpage to inform the colleagues and the students; discussing the case of specific students with colleagues.</i>
Tutorials Polycopie+ Exercises sheets + previous assessment texts + e-mails from lecturer + his/her webpage + discussion with the students Students' productions (homework and assessments) + corrections	Assessment Exercises sheets + previous control texts + e-mail discussion with colleagues + students productions

Table 2: Evolution of the documentation system: from tutorials to lectures as an enrichment of the documentation system (in italics the lecturer additional part)

(Chevallard, 1985), to produce content accessible for first or second year students.

Digital resources: An increasing, yet limited use

Proposing the polycopie, the exercises sheets, the previous exam texts on his/her professional webpage is done by 3 of the 4 lecturers. The lecturer's webpage is a central resource for the communication from the lecturer to his/her colleagues and his/her students. In general, the use of digital resources for the communication between colleagues, or with the students is a very important evolution, observed by each colleague. Information about the students is available on the university Virtual Learning Environment. Complementary information, such as the official curriculum, students' photos, is provided by the mathematics department website. The discussions within the team of teachers of a given teaching unit, the information on the course progress by the lecturer(s) for the teachers of tutorials are made via e-mail. Some students also write e-mails to teachers, but the in person discussion at the end of the lecture or tutorial remains the main communication mode, between students and teachers.

Nevertheless the use of digital resources remains limited, compared for example with secondary school (Gueudet *et al.*, 2012). The six colleagues declare that they do not search for Internet resources to prepare their courses, considering that they will not find something corresponding to their precise teaching objective. The use of the calculator by students is allowed during tutorials, but forbidden for the assessments.

For four out of the six teachers I interviewed, the use of technology seems to be restricted to their documentation system for communication.

I observe a different situation for two colleagues, contributing to two special teaching units: one about symbolic computation (Doris) and the other about numerical analysis (Bob). These teaching units encompass in particular, aside the tutorials, "practical works" in a computer lab. I consider here more precisely the case of Doris. Doris uses Maple for all the aspects of the teaching: lecture, tutorials, practical work – except for the assessment. She has developed different documents involving Maple, and has in particular a strong belief about the link between writing algorithms, programming them, and learning mathematics:

Doris: They work with algorithms by programming them. This way they can evaluate their efficiency, and see if they are useful.

She uses also Maple in her own research. For this special course, the resources for teaching and the resources for research have a significant intersection: Maple, and associated computer programs. The same situation happens for Bob in numerical analysis, with Scilab. In these cases, the course is designed for mathematics majors, and concerns a topic linked with the teacher's research; there is an associated link between the resource system for teaching and for research.

CONCLUSION AND PERSPECTIVES

The documentation systems of the six university teachers interviewed could be classified in three categories: Lecturer, for a “usual” teaching unit; Lecturer, for a teaching unit involving a specific software; Novice teacher (here PhD student), giving only tutorials in a “usual” teaching unit. The novice teachers' systems encompass only three subsystems: tutorials, assessments, communication; while the lecturers' systems also have a subsystem for lectures, and a more developed communication subsystem (see Table 2). Naturally other kinds of documentation systems exist, for other cases. Nevertheless these six systems have interesting common features and differences.

For all of them, the polycopie, the exercises list, and the previous assessments texts are crucial resources. None of them incorporates resources (exercises, mathematical texts) found on the Internet. This situation is completely different from the documentation work of secondary school teachers in France (Gueudet et al., 2012). Searching for resources on the Internet is a very usual practice in this context, in particular for the choice of “introductory activities” (problem texts, aiming at the introduction of a new concept or method). In fact such introductory activities do not exist, in the teaching at this university. The new concepts and methods are presented in the lecture, and then applied during the tutorials.

Novice teachers progressively develop their documentation systems. They firstly develop documents for the tutorials; then for the assessment, being involved in the collective preparation of assessments' texts. Along this work, they develop schemes which incorporate beliefs shared with their more experienced colleagues. Starting to give lectures is another step, which can lead to the development of more personal beliefs, in particular for a new lecture with no previous polycopie.

In the documentation systems for teaching units involving a specific software, this software is a crucial resource. Otherwise, only technologies for communication intervene, with the lecturer's webpage playing a central role.

Naturally this study remains limited, since I only met six colleagues, all of them working at the same university. Other universities can have different teaching

strategies, kinds of resources, different organisations, or local projects that shape the documentation work of teachers. I intend to extend this work, nationally and internationally. Another perspective is also to deepen this work by meeting again the six teachers interviewed, and by observing their courses to confront their actual practice with their declarations.

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APPENDIX: INTERVIEW GUIDELINES

This interview concerns resources (mostly material resources), intervening in your teaching for the first or second university year. Our aim is to understand which resources you use, which resources you design for your students etc.

Years of experience in teaching: Research domain:

- 1) Let us consider a teaching you did this year, for example « linear algebra in year 1 ». Which resources did you use, and design, for this teaching? For the lectures, if you gave lectures; For the tutorials or practical works; For the preparation of the intermediate assessments and exams texts.
- 2) About digital resources: do you use a professional webpage, a virtual learning environment, specific software? Do you use online resources to prepare your courses, do you project slides during your courses?
- 3) About collective work: do you work with colleagues to prepare your teaching? Which kind of work do you make for your teaching with colleagues?
- 4) For experienced teachers: which evolutions do you retain in the last 10 years, concerning the resources you use and design for your courses? For novice teachers: do intend to modify your teaching next year, how and why?
- 5) Link with research: are there resources that you use both for your research and for your teaching? Or other links, between your teaching and your research?
- 6) Did I forget to mention important resources, or something else that you consider important concerning your teaching?