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Conceptions in France about mathematical modelling: Exploratory research with design of semi-structured interviews

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From ongoing research, we present the design of interviews on conceptions about modelling in order to better know the relations between students, teachers, researchers, authors of resources and decision makers in the field of mathematical education in France. The theoretical framework combines theories on conceptions, on modelling and on anthropological approach. The methodology uses bibliography, exploratory data analysis, comparative approach and interviews. We describe how a review of the literature, an exploratory data analysis of existing questionnaires and interviews are used to design these semi-structured interviews.

Keywords: Modelling, interview, France, teacher, conception.

DESIGN OF INTERVIEWS ON CONCEPTION ABOUT MODELLING

Philipp (2007) points that teachers' conceptions play a key role in the teaching and learning of mathematics. Kaiser (2006) remarks that German "teachers and their beliefs concerning mathematics must be regarded as essential reasons for the low realisation of applications and modelling in mathematics teaching". CERME has reported several research on teachers' conceptions about modelling as we will show later in the review of the literature. We found only one research, (Cabassut & Villette, 2011), dealing with French teachers' conceptions: it was limited to French primary school teachers attending a teacher training course on modelling. *The problematic of our ongoing research* is the following: What are conceptions about modelling in France? What are their relations with the practice of modelling? The answers to these questions will help to understand differences and similarities

with conceptions in other countries and to produce resources taking into account French conceptions: for example to produce resources considering difficulties or obstacles expressed in French conceptions. The *focus of this paper* is at the beginning of the exploratory phase of this ongoing research. We describe the design of interviews and we expose how Chevallard's levels of didactic codetermination will help us to analyse the French conceptions. Hypotheses and results about French conceptions are not the focus of this present paper and will be produced in another paper. *The results of this exploratory phase proposed in this paper* are the theoretical framework, the review of literature and the design of interviews. Let us now describe our theoretical framework.

CONCEPTIONS ABOUT MODELLING

In many researches, different terms such as beliefs, emotions, attitude... are used to refer to similar concepts. We will adopt the definitions given by Philipp (2007), particularly: "Knowledge – beliefs held with certainty or justified true belief [...]. Conception – a general notion or mental structure encompassing beliefs, meanings, concepts, propositions, rules, mental images, and preferences". The general term "conception" allows us to avoid the debate on the differences between "beliefs" and "knowledge" and to concentrate on the interaction between teachers' conceptions and teachers' practice.

Maaß (2006, p. 115) expresses: "Modelling problems are authentic, complex and open problems which relate to reality. Problem-solving and divergent thinking is required in solving them". This conception and other ones collected in the review of the literature are considered in the questionnaire but it is not the

focus of this paper to discuss them. The extract of the interviews in part 6 shows how these conceptions are taken into account and how the future answers could express them.

ANTHROPOLOGICAL APPROACH

To help analysing these conceptions, we use Chevallard's levels of didactic codetermination as suggested in Barquero, Bosch & Gascón (2011, p. 1938). At the *level of mathematic discipline*, we ask questions about mathematic conceptions and practices in order to observe relations with modelling conceptions and practices, and to point what is specific to modelling and what is general to mathematics. For example in the interview, some open questions are: "What are mathematics for you? What is mathematic teaching for you? How do you teach mathematics? How easy is it?" Examples of question with Likert scale: "from my point of view, in my mathematic lessons, school mathematics is the memorizing and application of definitions, formulas, mathematical facts and procedures." About practice with a Likert scale: "In my mathematic practice it is important to do open problem solving". At the *level of domain*, we can consider modelling as a transversal domain, covering different mathematical domains. We ask questions about modelling conceptions (already mentioned in part 2) and its practice. At the *level of pedagogy* for example we ask "In my mathematic teaching practice is it important to do small group work?" At the *level of school*, in the biography part, we ask in what type of teaching institution (primary school, general, technical or vocational secondary school, tertiary education) the teacher works. To consider the *level of society* the semi-structured interviews will be adapted to different types of members of French mathematical educational sphere, in order to conjecture how teaching, training, resource and decision making contribute to the conceptions and practices of modelling. The *French mathematical educational sphere* gathers students to become mathematics teachers from different types of school, researchers, authors of resources and decision makers (mathematical supervisor, curriculum adviser, etc.) in the field of mathematical education. At the *level of civilization*, Cabassut and Ferrando (2013) show how PISA and European parliament recommendations are explicitly mentioned in French common base of knowledge and skills that encourage modelling. We adopt a comparative approach involving others coun-

tries (Switzerland, Spain and Germany) to conjecture variations between different cultures.

The role of the different levels of didactic codetermination resulting of the semi-structured interviews will be interpreted with help of other studies on modelling. At this point of our research we just prepare the way to collect all the interviews and are waiting for their results to be analysed through the grid of levels of determination.

METHODOLOGY OF EXPLORATORY RESEARCH

We will describe now the four components of our exploratory methodology, method of interviewing, review of literature, exploratory analysis of existing data and comparative approach, which will all help us to design the interviews.

Semi-structured interview

Among the different ways of collecting conceptions about modelling, we choose semi-structured interviews proposed by Bernard (2006, p. 212). For every topic within the interview, we ask at first some open questions without directive contents to enable the interviewed person to express freely his or her mind without direction given by interviewer. The topics are selected from a review of modelling research literature. In a second part, the answers are completed with directive closed questions in order to cover entirely the topics. This second part will be the base of a future written questionnaire that will be produced for confirmatory research. The questions are selected from a review of modelling research literature: LEMA project (Maaß & Gurlith, 2009), Schmidt (2011), Borromeo and Blum (2013). Some questions are adapted from inquiry based research: Dorier and Garcia (2013), Engeln and colleagues (2013). They often use the 5 levels Likert scale.

The semi-structured interviews are particularly adapted to researchers, authors of resource and decision makers because they are not so numerous in comparison with students or teachers, sometimes it is difficult to contact, and they have often time constraints that make harder to get a written answer to a questionnaire from them. Finally, after the exploratory research, we will produce a questionnaire to test the hypotheses. A cluster analysis of people answering the questionnaires could be produced, delivering for every cluster a representative paragon of

the cluster. An additional clarifying semi-structured interviews could be made with clusters paragons in order to make the results of the analysis of the questionnaires answers clearer. This shows how interesting semi-structured interviews are.

Review of literature

The review of literature concerns the two last CERME proceedings, the last three years of Educational Studies in Mathematics review, and of Zentralblatt für Didaktik der Mathematik, the proceedings of ICTMA 14 and other papers found on the internet or known by the authors. These review deals with research papers on conceptions about modelling in the mathematical educational sphere. We would like to remind the reader that we did not find research on conceptions of modelling specific to France, and that every collected research studied a specific population (for example primary school teacher or prospective secondary teacher) and none studied the conceptions of researchers, authors of resources and decision makers.

Exploratory analysis of existing data

The LEMA project described in Cabassut and Mousoulides (2009) has developed a teacher training course on modelling. During the project, two different kinds of data were produced. First, 83 teachers attended a LEMA pilot training course and have answered a questionnaire before and after the training in order to evaluate the training course. The questionnaire is well described in Maaß and Gurlitt (2009). Secondly, 3 French teachers have been interviewed after the LEMA training course to evaluate the impact of the training course. We propose an exploratory analysis of these data to explore these teachers' conception about modelling in the way suggested by Tukey (1977): we use descriptive statistic to observe existing data without preconceptions and without formulating hypotheses in advance. We do not use inferential statistics to test, in a deductive way, hypotheses formulated in advance on data to be collected for the research: that will be the job of confirmatory analysis.

For the 83 teachers, the questionnaire is composed of questions (variables) with multiple-choice qualitative answers and questions with quantitative answers. We split the variables in two parts: the biographical variables (country, age, gender, type of school...) and the active variables on conceptions about mathematical modelling. We will process a cluster analysis (as de-

scribed in Cabassut & Villette, 2011). For every cluster we will consider the splitting active variables. A *splitting active variable* is an answer for which the percentage of the answer in the cluster is very different than in the whole population. Every cluster will be described through these splitting variables. The biographical variables are also split by clusters. Some of them are *split variables* when the percentage of the answer to this question in the cluster is very different than in the whole population. The splitting and split variables are essential because they enable to explain heterogeneity and differences that are not shown by aggregated statistic indicators.

From the previous cluster analysis, three French primary school teachers belonging to different clusters were interviewed at the time of the LEMA project. This interview will be mentioned in this paper as *LEMA interview*. The LEMA interview is analysed as suggested in Creswell (2007, pp. 156–157) for grounded theory approach: transcription and reading, reduction to different categories and development of relations between categories.

It is not the focus of this paper to explain how the answers to the questionnaire will be analysed. But we can mention that a cluster analysis similar to the previous one will enable the description of every cluster with biographical variables (country, age, experience, job and education), mathematic conception variables, modelling conception variables, and variables about difficulties by modelling teaching. Interpretation of these clusters through levels of determination and additional clarifying interviews with clusters paragons will complete this analysis.

Comparative approach

We will also adopt a comparative approach as suggested in Cabassut (2007) to observe the levels of determination of modelling conceptions in different countries. The levels of determination can appear explicitly (in the questions or in the interview) and implicitly in the possibility to compare the answers between countries. The interview guide has to be formulated clearly for each country of the project: we will be aware about countries cultural references and translation issues. For example the expression “inquiry based approach” is not translated word by word: we use “*démarche d'investigation*” in French and “*problema de investigación*” in Spanish.

In the chronology of designing the semi-structured interview, we started from an existing questionnaire of LEMA project that was modified in a dialectic process with every new review of papers, results of exploratory analysis of existing answers to LEMA questionnaire, results of LEMA interview, and discussions between the two authors of this paper. As resulting process, the different parts of semi-structured interviews are defined. Then, the general questions introducing each part for the non-directive part of the interview are formulated and completed. Thus, for the directive part, the corresponding questionnaire is completed. The guide is adapted for every category of *mathematical educational sphere*. We choose to present now every part by illustrating it with questions and their justifications from literature and existing analysis.

DESIGN OF SEMI-STRUCTURED INTERVIEW

Research shows that biographical questions, within the first part of interview, play an important role in the teaching of modelling. Cabassut and Villette (2011) show that country, age and type of school are split variables. Borromeo and Blum (2013) show differences between teachers who studied mathematics as a subject or not; Borromeo and Blum (2013) and Kuntze (2011) identify the influence of experience in teaching mathematical modelling, what Cabassut and Villette (2011) identify as split variable. Dorier and Garcia (2013) point the importance of initial training.

The second part deals with the conceptions and practice about mathematics and can be introduced by the following questions “What are mathematics for you? What is mathematic teaching for you? How do you teach mathematics? How easy is it?”. As pointed by Maaß and Gurlitt (2009) “teacher’s knowledge and beliefs about the nature of mathematics [...] influence how they design or select tasks, plan, implement and evaluate their lessons”. Also Lee (2012) pointed “the significant impact of teachers’ knowledge and beliefs on their interpretation and implementation of curricula and daily teaching practices”. We keep the splitting questions of LEMA dealing with mathematical beliefs (Cabassut & Villette, 2011).

An interviewee from LEMA interview mentions that the difficulty related to heterogeneity is not specific to modelling problem but general to every mathematical problem. Another interviewee asserts that there are

no more difficulties in modelling situations than in ordinary ones. Another one mentions group management difficulties. For this reason we ask questions about difficulties in mathematic, to be compared with the difficulties about modelling.

The third part of the interview deals with conceptions and practice about modelling. If the interviewed person does not understand the word “modelling” and to enable him to go on with the interview, we suggest a possible definition based on Maaß definition mentioned on previous part on modelling conception. Borromeo and Blum (2013) are also defining modelling and LEMA questionnaire suggests an example of modelling task. About practice, Borromeo and Blum (2013) show the influence of experiences in teaching mathematical modelling concerning barriers and motivations. They point also the importance of training on modelling, which can only be learned effectively if there are teachers that have competencies in this field. An interviewee from LEMA interview expresses needs to create a lot of modelling situations to be used during teaching. In following part 6, the extract of interview guide is related to conceptions and practice about modelling.

The last part deals with difficulties about modelling collected from international research to observe how these are perceived in the French *educational sphere*. We selected six topics: time, assessment, lesson organisation, context, students’ involvement and resources. This selection is explained by the following reasons. Schmidt (2011) and Borromeo and Blum (2013) find time, assessment and resources as the three main difficulties by German teachers. An interviewee from LEMA interview mentions he needs time to keep the modelling process in class. Additionally, Borromeo and Blum show that “for 50% of the teachers, “time” is seen as a barrier”. But when it is a barrier for inexperienced teachers, it is not the case for experienced teachers; they observe the same difference about material. From the questionnaire of Engeln and colleagues (2013) on inquiry-based learning, we adapted some items to modelling: for example “to find modelling problems for the class I use textbook?”. Concerning assessments, Borromeo and Blum point that “teachers who did not study mathematics see here a barrier to teach modelling and for the other teachers “assessment” is a strong motivator”. About lesson organisation, Borromeo and Blum show that lesson-planning is relevant for the teacher but it is not necessarily seen as an obstacle; for several teachers

it is a motivation. Cabassut and Villette (2011) find splitting variables about lesson organisation (for example, to design the lesson or to help student). An interviewee needs to prepare a lot for a modelling lesson. About the context, Borromeo and Blum point “systemic obstacles (such as expectations of parents, scientific associations and other pressure groups, regulation examinations)”. An interviewee from LEMA interview mentions that the syllabus is not an obstacle and can be interpreted in his mind. Sometimes “the resistance does not only come from teachers but also from students or maybe even parents or the society as a whole” (Dorier & García, 2013). The topic about students’ involvement is based on Borromeo and Blum’s questionnaire. This part about difficulties is illustrated in the following extract of the interview guide.

EXTRACT OF THE INTERVIEW GUIDE

This extract is from parts 3 and 4 of the interview guide for teachers.

Part 3 Conceptions on modelling

Do you know what means “modelling problem”? (Yes/No)

If yes go on. If no go to item « A possible definition of a modelling problem »

Open question

For you what is a modelling problem at school?

Complementary questions

For each of the following statements mark how much you agree (agree, rather agree, neutral, rather disagree, disagree):

- a modelling problem at school is related to real world
- a modelling problem at school deals with authentic data
- for a modelling problem at school, there is only one solution
- a modelling problem at school is an open problem
- a modelling problem at school requires an inquiry based approach
- pupils have to be familiar with the context of the modelling problem

A possible definition of modelling problem

We consider a possible definition of modelling problem and other terms.

A modelling problem is:

- a problem (no immediate answer),
- open (it could be necessary to make some parts clearer: questions, data, hypotheses, mathematical solution, way to find a solution...)
- complex (many steps to solve the problem, some data have to be searched, discovery of a new type of solution...)
- related to real world (the context of the problem is related to reality on the contrary of some abstract mathematical problems)
- using mathematics and inquiry based approach to find a solution. How much do you agree this definition? (agree, rather agree, neutral, rather disagree, disagree)

Modelling practice

Open question

Do you use, in your teaching, problems that are open, complex, related to real world, and solved with mathematics and inquiry based approach? How? What resources do you use?

Complementary questions

How often do you use the following types of problems in class? (often, rather often, rather not often, often)

- Modelling problems
- Problems to be solved with inquiry based approach
- Authentic problems from reality.
- Problems with data interpretation
- Open problems
- Complex problems
- Problems with more than one solution

Resources

To find modelling problems for the class I use: (often, rather often, rather not often, not applicable because I don’t use modelling)”

- textbooks
- internet
- exchanges with colleagues
- exchanges with pupils or students
- other resources

Mention the other resources

Part 4 Facilities and difficulties of modelling

Open question

Is teaching of modelling easy or difficult? Why?

Complementary questions

How much do you agree (agree, rather agree, neutral, rather disagree, disagree)?

Time

It takes too much time to prepare modelling task for teaching.

The work on modelling tasks in the classroom is very time consuming.

It takes too much time to assess modelling tasks.

When I teach modelling, I have not enough time left for other learning content.

It is difficult to estimate how long it takes to solve a modelling task.

PERSPECTIVE OF CONFIRMATORY RESEARCH

With the interview guide, several interviews will be addressed to different members of *educational sphere*. In a next step of research, the results of these interviews will help to formulate research hypotheses and to adjust the final questionnaire. Then, a large-scale questionnaire will be processed to confirm hypotheses. It is difficult to get answers to a questionnaire from some members of *mathematical education sphere*. In this case the questionnaire will be replaced by an interview. “Finally, the question of how culture-dependent task-specific convictions of mathematics teachers related to modelling are merits attention in corresponding comparative research” (Kuntze, 2011). It is why all this research includes a comparative component to study the role of the different levels of determination when the context varies. This confirmatory research and its analysis will be the last step of our study.

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