

Teaching didactics to lecturers: a challenging field

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Lecturers' professional activity is, at least, twofold: research and teaching. However, their professional development is generally mostly based on research achievements and little effort is made to empower lecturers overcome the difficulties experienced during their teaching activities. We postulate that didactics of mathematics can be a powerful tool to help lecturers question and reorganize the knowledge to be taught, and to make them aware of the conditions enabling and the constraints hindering new modalities of teaching mathematics, more based on its use as a modelling tool to approach open questions. We present in this paper a first edition of a professional development course for lecturers designed for and experienced in an Engineering School in Barcelona. The results obtained are then used for a subsequent course redesign to be conducted with lecturers of a similar university school.

Keywords: Lecturer education, mathematical modelling, Anthropological Theory of the Didactic

Introduction

Traditionally, lecturers' development courses have not been considered relevant by research in teacher education. This is a normal phenomenon considering universities' criteria when hiring lecturers and evaluating those already lecturing: mainly research activities and merits are considered. In contrast, lecturers' didactic or pedagogical education is usually ignored or, at most, considered as a positive complement. The absence of regular lecturers' teaching training is a worldwide phenomenon with few – and not always successful – exceptions. In the United Kingdom, the Higher Education Academy (HEA), the UK Professional Standards Framework (UKPSF) and its accreditation process made a first attempt to incorporate lecturer training as a requirement to teach in UK universities (Department for Education and Skills, 2003). Nevertheless, this program that was thought to be central in lecturers' professional development has finished as a volunteer training and accreditation scheme for both individuals and institutions involved in teaching at higher education (The Higher Education Academy, 2011).

We consider that, as long as their activity has a clear twofold character based on research and teaching, in addition to the traditional training in research (Master's Degree and PhD program), lecturers also need an explicit pedagogical and didactic education. In fact, universities are among the sole existing teaching institutions where teachers are not required an explicit training course on teaching and learning processes. We consider that this crucial difference should not be accepted as a given: the conditions of existence of a university teacher education course have to be studied, especially with the possibility to base it on contents emerging from research in didactics.

In order to have a first set of empirical data to evaluate the conditions of existence of such a course for lecturers at university level we designed a course for 14 lecturers of an Engineering School in Barcelona (www.euss.es). Lecturers participating in the course teach Analysis (3), Strength of Materials (4), Physics (2), Electronical Technology (2) and Informatics (2). We took as starting point the frame of “study and research paths for teacher education” (SRP-TE) based on recent investigations in the Anthropological Theory of the Didactic (ATD) for pre-service and in-service secondary teachers. The lecturers’ course was experienced in February 2016. We present the design principles and results of this first edition, as well as the subsequent re-design for new editions, to overcome the experienced difficulties and take advantage of its potential strengths.

University teacher education: a field to be explored in ATD

Courses for pre- and in-service lecturer professional development are an unexplored field in research. There exists very little literature regarding this subject and the few experiences reported involve only general pedagogical contents not taking into account the very nature of the knowledge involved in the teaching and learning processes. It is important to highlight that no paper on this field was presented at the last CERME9 (neither at TWG 14, *University Mathematics Education*; or at TWGs 18, 19 and 20, *Teachers’ Knowledge, Practices and Education*), or at groups regarding teacher training or university teaching at the last ICME 13, except for a preliminary version of this paper (Florensa, Bosch, & Gascón, 2016b). The structure of ICME13 Topic Study Groups about teacher education is especially revealing at this respect: there were four groups on teacher education, two (in and pre-service) centered on the elementary level and two on the secondary level, but none on the tertiary level. At the recent conferences on Mathematics Education in North America, only Ellis presented research on teacher assistants training (Ellis, 2014a, 2014b).

Regarding the presence of papers in journals about lecturers’ education we have found very little production: only two papers (Guasch, Alvarez, & Espasa, 2010; Postareff, Lindblom-Ylänne, & Nevgi, 2008) and the *Handbook on Teaching and Learning in Higher Education* (Fry, Ketteridge & Marshall, 1999). We have developed a research from the initial year of publication to the end of 2015 in these journals: *Educational Studies in Mathematics*, *Higher Education*, *Journal of Mathematics Teacher Education*, *Mathematical Thinking and Learning*, *Journal of Teacher Education*, *Recherches en Didactique des Mathématiques*, *REDIMAT*, *RELIME*.

As said before, we consider that research in didactics can be taken as the basis for courses on lecturer education regarding teaching and learning processes. We assume as starting hypothesis that results emerging from secondary teacher education can be used at this level. The results presented in this paper will be used to partially confirm this assumption. The *Solid Findings in Mathematics Education on Teacher Knowledge* (Education Committee of the EMS, 2012) state explicitly that “content knowledge” (CK) is necessary but not sufficient for teaching. The report of the Education Committee highlights as crucial notions to be developed in teacher education the “pedagogical content knowledge” (PCK) (Shulman, 1987) and the different dimensions of the “mathematical knowledge for teaching” (MKT) (Ball, Thames, & Phelps, 2008). Both approaches clearly go further than the traditional conception of teaching as transmission of knowledge and consequently

ask for changes in teacher education concerning the way mathematical knowledge should be approached.

We use the Anthropological Theory of the Didactic (ATD) as a main framework for the design, experience and analysis of the course. The last investigations on teacher education in ATD show that the use of notions such as PCK and MKT do not ensure researchers/educators to include a questioning of the nature, selection and organization of the contents to be taught (Ruiz-Olarría, 2015). Under the ATD approach, the role of teacher education is not limited to enrich teachers' pedagogical performance, but also to provide them with tools to contest the so-called *dominant epistemology* and emancipate from it when designing study processes (Gascón, 2014).

This questioning and reorganization of the knowledge to be taught is not spontaneous for teachers (nor for lecturers) because they tend to assume the institutional dominant epistemology as their own. The way proposed by ATD research to locate it at the core of teacher educational processes has very much evolved in this last decade. It started with a first experience in secondary teacher education based on the “questions of the week” (Cirade, 2006) and nowadays takes the form of an inquiry-based device called “study and research path for teacher education” (SRP-TE), which starts from a problematic question appearing in the field of the teacher profession and leads to the search, development and analysis of alternative teaching proposals (Barquero, Bosch, & Romo, 2015, 2016). The main idea of the SRP-TE is to generate a practical and theoretical questioning of the school activities linked to the teacher professional initial question. It is structured in five modules:

- M0: Formulation and first exploration of the generating question Q_0 of the SRP-TE, for instance one of the kind: “How to teach (a specific content)?” which is to be partially answered at the end of the process.
- M1: Living a “study and research path” (SRP) as a student. The main goal is to make teachers encounter an unfamiliar inquiry-based activity related to Q_0 that could exist in a normal classroom of the considered educational level.
- M2: Adaptation of the lived SRP to be experienced in a real school situation. During this adaptation, many of the institutional restrictions teachers should face are expected to show up. They can thus be afterwards analyzed from an epistemological, didactic and *ecological* perspective (what can “live” and under what conditions in a given educational setting).
- M3: Experimentation, management and carrying out of in vivo and a posteriori analyses of the adapted teaching proposal.
- M4: Joint elaboration of a critical analysis of traditional teaching practices and the possibilities (and limitations) of introducing new proposals, as well as generation of a partial answer to Q_0 .

During the development of SRPs-TE for secondary school teachers, an epistemological tool has been adapted and developed to facilitate the analysis of the SRP and the questioning of school contents: what we call “question-answer maps”. Following other authors, we consider these maps, which are used as a key tool in ATD research, as a powerful instrument for teacher education:

We hypothesize that such a representation is sufficiently close to teachers' concerns, and also captures such essential parts of a didactic design, that one could use it as a tool for collaboration and communication with and among teachers, regarding concrete teaching designs (Winsløw, Matheron, & Mercier, 2013, p. 281)

Some preliminary and promising experiences exist in using these maps in teacher training courses to describe the dynamic and collective aspects of mathematical activity (Barquero, Bosch, & Romo, 2016; Florensa, Bosch, & Gascón, 2016a; Jessen, 2014). The work with the maps seem to be useful for teachers in order to describe knowledge in inquiry activities and to act as a counterpoint of the official curricular organization of contents.

Research questions

The work presented in this paper is considered as an exploratory design (Singh, 2007) to obtain and analyze a first set of data from the first implemented course and to redesign it to be applied in another institution. The specific research questions that will be studied are:

- RQ1. The role played by question-answer maps in teacher education: Do they help lecturers describe, analyze and design inquiry and modelling processes and the involved knowledge?
- RQ2. Does the course empower lecturers to identify the dynamic and collective nature of the lived SRP in contrast to the static, individual and compartmentalized dominant conception of knowledge?

Course description

The engineering school where the course was implemented keeps a four-hour time slope with no teaching for all lecturers all Wednesdays: they use this time for professional development, meetings, pedagogical courses or activities. In fact, it is a Salesian university with a special concern about teaching and learning processes, as well as students' personal evolution. The course was structured in six two-hour sessions during three weeks, and the central question to be partially answered was: "Could modelling be the main motivation of my subject? Which conditions enable and which constraints hinder this modelling activity?"

Because of the time restriction, the five-module structure of the SRP-TE had to be adapted. The six sessions appeared to us (designers and course leaders) as a too short course. However, they finally seemed to be enough for the work planned. Of course the "true work" is to be carried out afterwards, when lecturers decide to introduce some new proposals in their subject based in the work initiated at the course. During this application phase teachers implementing SRPs asked for help to the researchers-educators, thus extending the real duration. We planned the course as follows:

- 1st session: Explicitly state the professional question Q_0 and shortly present the ATD framework including the notions of praxeology, Herbartian schema and media-milieu dialectics, topogenesis, mesogenesis and chronogenesis (Barquero & Bosch, 2013)
- 2nd and 3rd sessions: A SRP was proposed to be carried out in groups of up to three lecturers. "Taking into account the incidence index of the last 9 months of a dengue outbreak: could you forecast the incidence index for the next 3 months (already known)?" (Figure 1)

- 4th session: Lecturers generated a question-answer map of the lived SRP. One of the generated maps can be seen in Figure 2.
- 5th session: Lecturers are invited to create new small groups with the colleagues teaching the same subject. They are asked to design a SRP by choosing a generating question in their field trying to overcome some observed didactic facts such as the absence of *raison d'être*, the disconnections of topics or the poverty of the experimental work, among others.
- 6th session: Sharing some possible teaching proposals and conclusions of the course.

Year	Incidence index
0	31
1	179
2	438
3	454
4	587
5	1176
6	1543
7	1859
8	2373
9	696
10	0.1
11	0.05
12	0

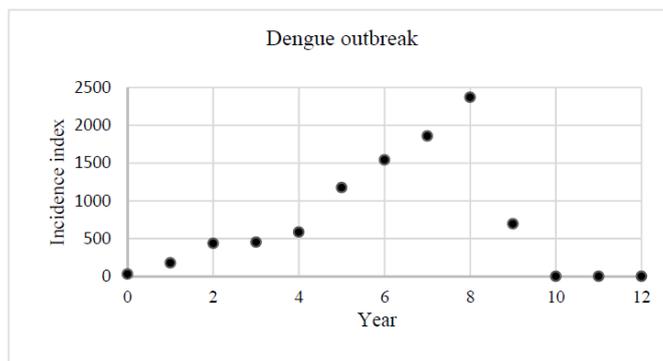


Figure 1: Data used for the lived SRP

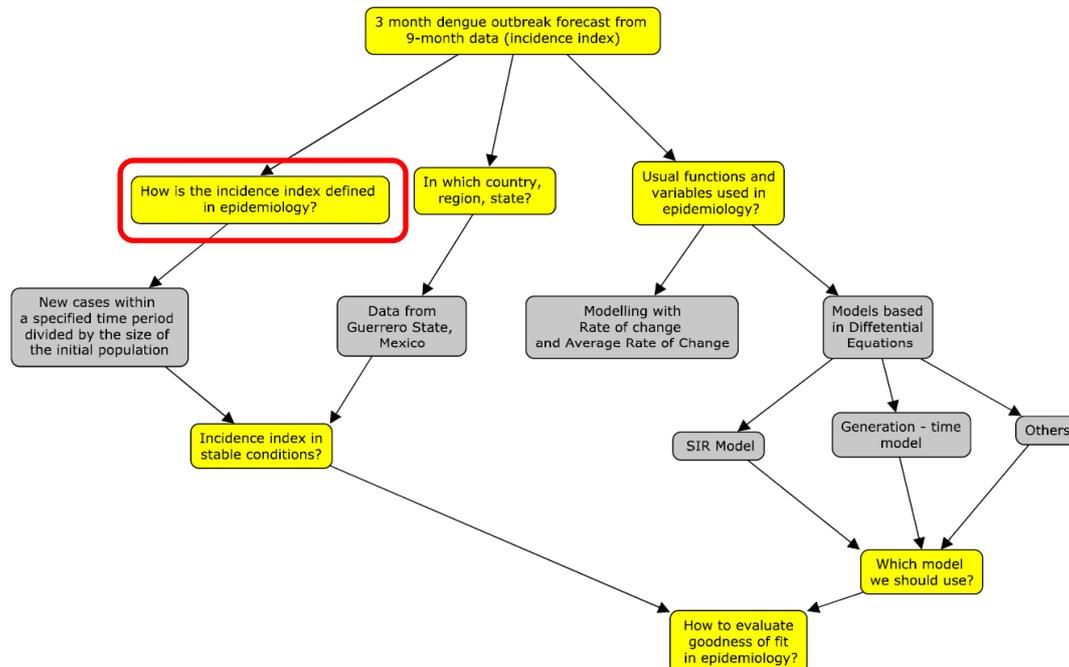


Figure 2: Question – answer map of one of the groups

In the introduction to the 5th session, lecturers were invited to identify didactic facts that they would like to overcome through the new didactic proposal. The goal was not to implement the inquiry by

itself, but to identify how the *dominant epistemology* in the institution is related to these problematic phenomena and roughly propose new possible epistemological and didactic organizations to face them. The question-answer maps were the tool provided to lecturers to carry out this work. During the implementation of the course, some of the contents that we initially considered as difficult had an easier reception than expected (especially the notion of media-milieu dialectics) and, on the contrary, some basic notions were difficult to share with the participants, for instance the description of contents in terms of questions instead of topics.

In order to obtain data to evaluate the course, all the questions-answer maps of all groups, both from the analysis of the modelling lived activity and from the a priori design of the SRP, were collected. We have also obtained data from a final survey filled in by all lecturers attending the course. The survey was structured in three main blocks. The first block addressed general aspects of the course such as duration, balance between individual and team work, time structure, etc. The second block asked about content-related aspects of the course like the work developed with question-answer maps and with the media-milieu dialectics. Finally, the survey asked the lecturers about the possible consequences of the course on their teaching activities: changes in the conception of knowledge, dynamics and collective aspects of activities, and availability of new designing and evaluating tools.

Results and discussion

The question-answer maps regarding the dengue outbreak SRP shew up how the inquiry was capable to connect fields usually disconnected in the traditional curricular organization of contents. For example, the map of Figure 2 reveals that functions, differential equations, regression, average rate of change and epidemiological notions are deeply interrelated. An interesting fact emerged when analyzing different maps from different working groups: depending on their lecturing field, they approached the problem quite differently. For instance, Mathematics lecturers' work was centered on finding a mathematical model fitting the data, whereas Chemistry lecturers' work evolved around the epidemiological data, the notion of "incidence index" and searching scholar literature regarding other similar outbreaks. The use of the maps was a key factor to describe this connection of fields usually lacking in school institutions.

The second part of the survey about the content of the course reveals that the work developed by lecturers with the question-answer maps and the media-milieu dialectics was difficult for them (more than 70% of the teachers found it hard or very hard) but at the same time they identified this work as "easily applicable to design and manage new teaching and learning processes" (more than 70% of the lecturers found contents and tools of the course easy to use and to implement). Regarding the consequences of the course on the lecturers' teaching practices, the survey showed that it helped (more than 90% totally agreed) to change their previous conception of knowledge towards a dynamical-collective conception in terms of modelling activities.

The third source of evidence are the maps generated by the lecturers as a priori analysis for an SRP to be experienced in their subjects. In total, six maps were generated by lecturers, all of them with a generating question and making explicit the didactic facts intended to be overcome. Two of these a priori SRP designs were experienced during the spring semester, starting just after the lecturers' course. These two emerging SRP have been experienced and managed only by lecturers that

followed the course and did not have any other didactic experience or training. This fact is especially interesting because with the analysis of these experiences a first set of data can be collected regarding the conditions of existence of SRPs at the university level led by lecturers with almost no direct connection with research in didactics. This first experience in lecturer education seem to preliminary validate Winsløw et al. (2013) hypothesis about the use of question-answer maps in teacher education and confirm Barquero et al. (2016) results. Lecturers have worked with the maps and have used them to both model a lived study process and a priori analyze their own designed SRP. Moreover, the maps have been used to compare the knowledge mobilized during a specific SRP and the school knowledge. The Q-A duplets appearing in the map were used as the elements to contrast with curricular requirements.

The course also appears as a good tool to empower lecturers to question and put under vigilance the *dominant epistemology* at the university. It produced a discussion (and thus enabled a reflection) on what knowledge has to be taught at the university and how the modelling activity with its dynamics and collective aspects could be considered. Regarding the conditions of existence of a lecturer course based on the ATD, it seems that the described conditions make it viable and that some lecturers have taken it as an opportunity to redesign their teaching and learning activities. However, an important aspect to take into account is the fact that one of the leaders of the course is also a lecturer in the considered Engineer School, what certainly affected the good predisposition of the attendees due to his personal leadership in the institution. This particular condition has to be considered in new editions of the course and the question of its reproducibility remains open.

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