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# Study and research paths at university level: managing, analysing and institutionalizing knowledge

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*After more than 10 years of designing, implementing and analysing study and research paths (SRP) at university level, we present a retrospective analysis of the SRP implemented in different university degrees. We focus on the main methodological tools for the SRP design and managing, together with some results about their viability at university level. We come across different SRPs and underline the methodological tools that have worked better. We also show how they have evolved to set up a more systematic methodology.*

*Keywords: Study and Research Paths, ATD, IBME education, didactic engineering.*

## Introduction

During the past two decades, Inquiry Based Mathematics Education (IBME) has spread widely. It has been promoted by governments and international organizations through specific programs and curricula reforms, such as the PRIMAS and Fibonacci projects in Europe, or the Common Core State Standards in the United States. Artigue and Blomhøj (2013, p. 802) describe how different research frameworks offer “particular perspectives on the conceptualization and implementation of IBME”. Their analysis reveals that there exists shared principles such as the “authenticity” of questions and activities; their epistemological relevance; the progression of knowledge; the development of extra-mathematical questions and the role of mathematics as a modelling tool in inquiry processes. One of the problems emerging from this diversity of approaches is that the concretion of IBME in research experiences may only rely on these general principles, lacking a clear systematic methodology to design, manage and analyse the implemented experiences, and to provide specific research tools to develop these tasks.

Study and Research Paths (SRPs) are an inquiry-based teaching formats proposed by the Anthropological Theory of the Didactic (ATD) (Chevallard, 2015). They are initiated by a *generating question* ( $Q_0$ ) addressed by a community of study (a set of students  $X$  and a set of guides of the study  $Y$ ) that form a *didactic system*  $S(X, Y, Q_0)$ . The aim of the didactic system is to generate a final answer  $A^\heartsuit$  to question  $Q_0$ . The work of the community of study and the knowledge involved can be described as a concatenation of derived questions and their associated answers that will led to the development of  $A^\heartsuit$ . The inquiry process will combine moments of *study* of information available, with moments of *research* and creation of new questions and answers, including the adaptation of the information to the specific (initial and derived) questions addressed.

The goal of implementing an SRP is twofold. On the one hand, SRPs can be understood as a teaching device to promote a shift from the pedagogical paradigm of “visiting works” to the new paradigm of “questioning the world” (Bosch, Gascón, & Nicolás, 2018; Chevallard, 2015). On the other hand, SRPs can also be considered as a research tool to identify, modify and study *didactic phenomena*, that is, regular facts that take place in teaching and learning processes and that are specific to the content involved. The implementation of SRPs is an empirical tool to generate data to evaluate to what extent and how *didactic phenomena* can be modified and to work on the definition and design of alternative epistemological and didactic models in which the knowledge at the stake and its related teaching practices are questioned and newly organised.

The ATD framework has developed diverse subtheories enabling researchers to analyse study processes and SRPs in particular. Two of these tools are the Herbartian schema (Chevallard, 2008) (see Fig. 1) and the media-milieu dialectics. The first part of the schema represents the *didactic system*  $S(X; Y; Q_0)$  that faces the task to generate an answer to an open question  $Q_0$ . The second part of the schema describes the process of elaboration of an answer ( $A^\heartsuit$ ) of the community of study to the generating question  $Q_0$ . The hallmarked answers and works are preexisting knowledge developed in different institutions that the community of study will access in the *media*. This information obtained is then studied, deconstructed and adapted to the (sub)question addressed and incorporated to the *milieu*. This *media-milieu* dialectic that explicitly appears in the Herbartian schema allows researchers to question and analyse the external information (and its diversity) addressed by the community of study and how it is validated.

$$[S(X; Y; Q_0) \mathcal{J} \{Q_1, Q_2, \dots, Q_m; A^\diamond_{m+1}, A^\diamond_{m+2}, \dots, A^\diamond_n; W_{n+1}, W_{n+2}, \dots, W_p\}] \curvearrowright A^\heartsuit$$

**Figure 1 Herbartian schema**

Following Artigue (2014), Barquero and Bosch (2015) have described four main phases in the design and research methodology related to Didactic Engineering: the identification of didactic phenomena; the design or a priori analysis of an SRP; the in vivo analysis of the SRP; and the evaluation or a posteriori analysis of the ecology and economy of the SRP. This is a crucial point of SRPs: including an explicit epistemological questioning differs heavily with other PBL approaches.

However, as Bosch (2018) and Florensa, Bosch and Gascón (2015) stated, this theoretical and methodological apparatus is difficult to be transposed to teacher and lecturers practice, especially when they are not at the same time familiar with the ATD framework. In fact, most of the experienced SRPs at university level have been led by researchers in the ATD or by lecturers working closely with them. In this paper, we present a retrospective analysis of previous SRP implementations at university level in order to identify the evolution of the used didactic tools. When examining this evolution, we intend to set up the foundations of a more systematic methodology for the design and managing of SRPs in university classrooms and for their viability.

## The experienced SRPs

Table 1 presents a brief account of the SRPs implemented during this past decade by the ATD research team based in Spain. Details of their design and implementation can be found in the references. Let us just point out that the integration of the SRPs has adopted different modalities to

be integrated in the traditional organization of the university courses. SRP1 and SRP2 ran as workshops in parallel to the regular course, as weekly 2-hour sessions for a total of 60 hours both, thus complementing the lectures and problem sessions. SRP3 consisted in an elective workshop that lasted about 9 sessions of 2 hours at the end of the course about forecasting the Facebook users' growth. SRP4 was fully organized as an SRP lasting a whole 6 ECTS subject (17 weeks, 4 hours per week). SRP5 was implemented after 8 weeks of lectures, labs and problem sessions, for the 7 last weeks of the course, thus covering a total of 21 h.

| SRP | Subject               | Level and degree  | Period    | References  |
|-----|-----------------------|---|-----------|---|
| 1   | Mathematics           | Population dynamics<br>1 <sup>st</sup> year Chemical engineering<br>(groups of 30-35 students)              | 2005-2009 | Barquero, Bosch & Gascón (2011; 2013)   |
| 2   | Mathematics           | Sales of products<br>1 <sup>st</sup> year Business administration<br>(groups of 40-60 students)             | 2006-2014 | Serrano (2013), Serrano, Bosch & Gascón (2010)  |
| 3   | Mathematics           | Evolution of Facebook users<br>1 <sup>st</sup> year Business administration<br>(groups of 20 students)      | 2015-2017 | Barquero, Monreal, Ruiz-Munzón & Serrano (2018)   |
| 4   | Strength of materials | How to make a slatted bed base?<br>3 <sup>rd</sup> year Mechanical engineering<br>(group of 20-25 students) | 2015-2018 | Bartolomé, Florensa, Bosch & Gascón (2018)  |
| 5   | General elasticity    | How to make a bike part?<br>2 <sup>nd</sup> year Mechanical engineering<br>(groups of 30 students)          | 2015-2018 | Florensa, Bosch, Gascón & Mata (2016) and Florensa, Bosch, Gascón & Winsløw (to appear) |

**Table 1. List of experienced SRPs by the ATD research team in Spain**

### **Dealing with knowledge in an SRP: the language of modelling**

The traditional “transmissive” way of knowledge dissemination at university level tends to sacralise the bodies of knowledge to be taught (Bosch, 2018). Therefore, tasks such as describing, organizing the work, collecting data, and searching well-established (and labelled) knowledge are not always part of the students' responsibility. And, when they are, they appear as non-problematic for the students, who only have to retake and at most summarize the accessed pieces of knowledge. In addition, the dominant pedagogical paradigm tends to hide the questions for which a specific knowledge is relevant, or at least leave them for the very end of the study process. These phenomena generate important constraints when implementing an SRP in a school institution. In the design and implementation of SRPs, the dialectics between the questions posed and the construction of answers is central, as well as the share of new responsibilities between teachers and students in the inquiry process. The development of tools enabling changes, especially those relating to the way “content” is described and managed, have appeared since the first implementations of SRPs.

Barquero, Bosch and Gascón (2013) present one of the first SRPs experienced at university level (SRP1). The SRP was implemented along the annual course of “Mathematical Foundations for Engineering” with students of Industrial Chemical Engineering, in the so-called “Workshop of

mathematical modelling” which was created only to develop the SRP and which ran in parallel of the regular course based on lectures and problem sessions. This three university teaching devices were easily coordinated because there was only one group of about 35 students and two lecturers, the one responsible of the theoretical sessions and the other (second author of this paper) who guided the problems sessions and the workshop. Although there was a study programme to accomplish, the lecturers-researchers had freedom to carry it out in the most convenient way. The generating question of the SRP was “How can we predict the long-term behaviour of a population size, given the size of a population over some previous periods of time? What assumptions should be made? How to forecast the population size’s evolution and how to test its validity?” The design and implementation of this SRP wanted to address the problem of teaching modelling at university level and to deal with the widespread didactic phenomena of reducing modelling activity to the simple “application” of some pre-established models and contents. Researchers designed the SRP paying special attention to the modelling process to be developed with students. The *a priori* design included a careful delimitation of the generating and derived questions that could be posed and of mathematical models and knowledge that would appear to provide answers.

One of the first necessities experienced by the lecturer guiding the modelling workshop was to share and institutionalise a new *discourse* to talk about the mathematical activity students were developing. In this occasion, most of the discourse needed was about modelling, which was quite new for the students. Introducing terms referring to systems and models, to the formulation of hypotheses, to the actions of validating the models or discussing the scope and limitations of the models, was a new *logos* for the students to describe, organise, justify and report their activities.

A second aspect highlighted by Barquero et al. (2013) is the necessity to create new didactic devices to transfer new responsibilities to the students who had “to produce their own answer [...] considering intermediate (sub)questions and write and defend a team report [...] with their temporary answers” (Barquero et al., 2013, p. 326). The main didactic devices to manage the implementation of the SRP and to institutionalize the modelling activities were the *weekly reports* that students developed and presented. From the second year on, these reports were based on an explicit fixed structure, including a description of the questions faced, the mathematical models built, the answers obtained, and the new questions proposed to follow with. Moreover, each team had to designate its own “secretary”, a student in charge of explaining and defending the team’s report at the beginning of each new workshop session. A whole class discussion followed these presentations, to state the main progress and to agree on how to continue with the inquiry. At the end of the SRP, each student individually had to write a *final report* of the entire study where she had to analyse the whole modelling process followed (Barquero et al., 2013, p. 327).

The implementation of SRP2 was initially done as a workshop that took place during the Mathematics course of a 1<sup>st</sup> year degree in Management. The workshop lasted for 5 weeks with two 2-hour sessions. The generating question of the SRP was: “A firm registers the term sales of its 7 main products during 3 years. What amount of sales can be forecasted for the next terms? Can we get a formula to estimate the forecasts? Which are its limitations and guarantees? How to explain them? What products sales are increasing more than 10% a term? Less than 12% a term?” It is important to highlight that the lecturers established two kinds of sessions: one devoted to

autonomous group work under the lecturers' supervision and another to share the results obtained and validate them by the big group.

### **From modelling to questions-answers maps**

SRP3 was initiated by the following question: "How can we model and fit real data about the evolution of the number of Facebook users to provide our forecasts about the short-term evolution of the users of this social network?" (Barquero et al. 2018). Its implementation took place in the academic years 2015-16 and 2016-17 with first-year students of a Business Administration and Innovation Management degree, at Pompeu Fabra University. It run as a teaching device created for its implementation called the "Modelling workshop" that was independent of the mathematics courses. Students voluntarily participated in the workshop, with the possibility of adding an extra point to their final mathematics grade. The responsible of guiding the workshop was the lecturer of the mathematics course who, for the first time, was not a researcher in the ATD. The workshop run for 2 hours every week for 9 weeks, although most of the modelling work was developed by students working in groups out of the class. This SRP combined online sessions and face-to-face sessions. The workshops sessions were devoted to students' presentations and to the debate about the questions posed, new questions to inquire and the models, tools and answers found out.

When designing the SRP, a group of researchers and the lecturer participated in it. In its design, the understanding of mathematics as a modelling tool was central, but the description of the "skeleton" of the SRP in terms of questions ( $Q$ ) and answers ( $A$ ) took the central role for many reasons. First, there was an intensive work in the designers' team to delimit the structure of the SRP in terms of  $Q$  and  $A$ , which define the epistemological models of reference upon which they started to plan and analyse the implementation—as proposed in other research works, Florensa, Bosch, & Gascón, 2018; Winsløw, Matheron, & Mercier, 2013).

Second, the weekly reports remained to be the main communication tool and were explicitly asked to be done in terms of questions and answers. To accomplish this, the virtual platform (called a c-book unit developed in the frame of the European project MCSquared) was extremely useful to provide students with dynamic tools to structure their reports (Barquero et al., 2018, p. 20-24).

Moreover, questions and answers maps were also used by the lecturer to analyse the development of each workshop session in collaboration with the researchers. It was then decided to start a *journal of implementation* as a tool facilitating the lecturer-researcher interaction and to report on the type of knowledge appearing in the inquiry process. As the authors describe, in this journal:

[...] the researchers indicated, before a workshop session, the questions they had to present, the way to organize student participation, some indications about the gestures and strategies they could follow, and so on. After each workshop session, the lecturers and researchers met to analyse the work of students, and compared it to the a priori design. (Barquero et al., 2018, p. 20)

SRP4 (Bartolomé et al., 2018) was implemented during the 2016/17 academic year in a "Strength of Materials" course of a Mechanical Engineering degree at Univ. Autònoma de Barcelona. The generating question of the SRP was: "You are working as an engineer in a company manufacturing slatted-beds. Your company supplies beds to an American client (a chain of motels). Recently, you

have been commissioned to provide them with single slatted-beds, capable of supporting the weight of a 120 kg person”. The SRP was implemented during the whole semester in all the sessions (17 weeks, two 2-hour sessions per week). In this work the management and description of knowledge was done using question-answer maps. This tool played an important role: it allowed both students and lecturers to communicate and they were also used to describe the final answer. An important difference between previous implementation was the explicit training of participants in the use and development of this tool. During this initial training session, the students were informed that the sessions would be structured in four phases. The first part of the session was devoted to check the status of the project using a common question-answer map followed by a brainstorming session to decide the next question(s)  $Q_i$  relevant to the problem. In the second phase the group was divided in different small groups each tackling a specific question. The third phase was devoted to team work developing an answer to the assigned question. The final phase consisted on each small group presenting a specific Q-A map describing their answer to the whole group. Figure 2 exemplifies the Q-A after the two first sessions. In addition, SRP4 also included the *media - milieu* dialectic as a managing tool. During the four phases of the sessions, students described not only their work in terms of answers and new subquestions but also, they had to incorporate the *media* they used to grasp information to generate the answer. In addition, the students had also to justify their answer presenting proofs or data in order to show to what extent the acquired data and its study and modification were adequate to generate an answer to the question tackled.

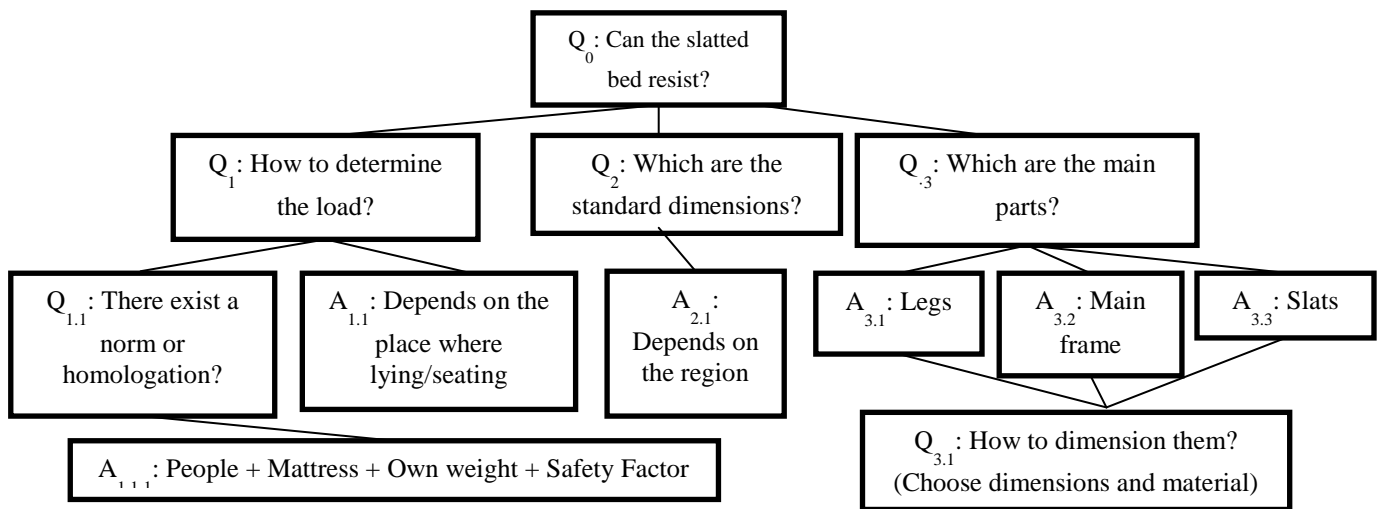
SRP5 was implemented in an “Elasticity” course in the same engineering degree than SRP4. In contrast, this SRP was implemented during the last 7 weeks of the semester, keeping the traditional structure along the 10 first weeks. In this implementation students were organized in small groups (3-4 students) and each group was in charge of designing and validating part of a machine (a bike for the first edition and a formula student car in the second edition). The assessment and management of the SRP was done using weekly reports in where Q-A maps become the main content. In contrast to the previous SRPs, the final report took the form of a technical report addressed to the company that commissioned the design work.

## Conclusions

The revision of different SRP implementations shows the evolutions that have occurred concerning the different didactic tools used in the design and managing of SRPs in university classrooms. We have focused on showing how, along the different investigations, these tools have been made available to the participants (students and lecturers) to deal with the knowledge and to organize the study processes. In addition, our retrospective study reveals that the tools needed by lecturers and students to manage and experience SRPs are diverse. We have identified aspects related to the language level: participants in SRP1 had to develop a specific terminology concerning modelling that was absent in the institution of study.

Another aspect relates to the need to describe and communicate how knowledge evolves during the inquiry process. Q-A maps have been satisfactorily adopted in different implementations helping teachers and lecturers to overcome this problem. Another useful aspect in one of the implementations is the transposition of the *media-milieu* dialectics—a research tool of ATD—to

help teachers and students organise their work. Making the search for information in the media and its confrontation with or integration into the milieu explicit helped to assign tasks.



**Figure 2: Initial Q-A maps generated during the SRP concerning the dimension of a slatted bed (Bartolomé et al., 2018)**

Another aspect that our study has identified is that the degree of explicitness of the implemented tools is increasing in each implementation. In the last editions of the SRPs, working with lecturers that were not researchers in didactics required a presentation of the ATD tools used. Finally, it is important to highlight that these tools (Q-A maps, media-milieu dialectics) come from the research and have been transposed to the community of study level for its use. We consider that these findings should encourage the community of researchers to more systematically use these tools in further SRP implementations. It seems to be a promising way to deal with some of the institutional constraints that have been found to hinder the dissemination of SRPs in university education, especially those related to the lack of epistemological terms to deal with inquiry processes.

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### References

- Artigue, M. (2014). Didactic engineering in mathematics education. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 159–162). Netherlands: Springer.
- Artigue, M., & Blomhøj, M. (2013). Conceptualizing inquiry-based education in mathematics. *ZDM - International Journal on Mathematics Education*, 45(6), 797–810.
- Barquero, B., & Bosch, M. (2015). Didactic Engineering as a Research Methodology: From Fundamental Situations to Study and Research Paths. In A. Watson & M. Ohtani (Eds.), *Task Design in Mathematics Education- ICMI Study 22* (pp. 249–273). Springer.
- Barquero, B., Bosch, M., & Gascon, J. (2011). ‘Applicationism’ as the dominant epistemology at university level. In M. Pytlak, T. Rowland, & E. Swoboda (Eds.), *Proceedings of CERME7* (pp. 1938-1948). Rzeszów, Poland: University of Rzeszów and ERME.



- Barquero, B., Bosch, M., & Gascón, J. (2013). The ecological dimension in teaching of mathematical modelling at university. *Recherches en Didactique des Mathématiques*, 33, 307–338.
- Barquero, B., Monreal, N., Ruiz-Munzon, N., & Serrano, L. (2018). Linking Transmission with Inquiry at University Level through Study and Research Paths: the Case of Forecasting Facebook User Growth. *Int. Journal of Research in Undergraduate Math. Ed.*, 4(1), 8–22.
- Bartolomé, E., Florensa, I., Bosch, M., & Gascón, J. (2018). A ‘study and research path’ enriching the learning of mechanical engineering. *European Journal of Engineering Education*, 1–17.
- Bosch, M. (2018). Study and Research Paths: a model for inquiry. In B. Sirakov, P. N. de Souza, & M. Viana (Eds.), *International congress of Mathematicians* (Vol. 3, pp. 4001–4022). Rio de Janeiro: World Scientific Publishing Co. Pte. Ltd.
- Bosch, M., Gascón, J., & Nicolás, P. (2018). Questioning Mathematical Knowledge in Different Didactic Paradigms: the Case of Group Theory. *International Journal of Research in Undergraduate Mathematics Education*, 4(1), 23–37.
- Chevallard, Y. (2008). Afterthoughts on a seeming didactic paradox. In J. Lederman, N. Lederman, & P. Wickman (Eds.), *Efficacité & Équité en Éducation* (pp. 1–6). Rennes.
- Chevallard, Y. (2015). Teaching mathematics in tomorrow’s society: a case for an oncoming counter paradigm. In S. Cho (Ed.), *Proceedings of the 12th International Congress on Mathematical Education* (pp. 173–187). Seoul: Springer International Publishing.
- Florensa, I., Bosch, M., & Gascón, J. (2015). The epistemological dimension in didactics: Two problematic issues. In K. Krainer & N. Vondrova (Eds.), *Proceedings of CERME9* (pp. 2635–2641). Prague, Czech Republic: Charles Univ. in Prague, Faculty of Education and ERME.
- Florensa, I., Bosch, M., & Gascón, J. (2018). Reference epistemological model: what form and function in school institutions? In H. Chaachoua & M. Bosch (Eds.), *6th International Conference on the Anthropological Theory of the Didactic* (pp. 22–26). Autrans.
- Florensa, I., Bosch, M., Gascón, J., & Mata, M. (2016). SRP design in an Elasticity course: the role of mathematic modelling. In Nardi, E., Winsløw, C., & Hausberger, T. (Eds.) *Proceedings of INDRUM 2016* (pp. 191–200). Montpellier, France: Univ. of Montpellier and INDRUM.
- Florensa, I., Bosch, M., Gascón, J., & Winsløw, C. (2018). Study and Research Paths: A New tool for Design and Management of Project Based Learning in Engineering. *International Journal of Engineering Education*, 34(6), 1848–1862.
- Serrano, L. (2013). *La modelización matemática en los estudios universitarios de economía y empresa: análisis ecológico y propuesta didáctica*. Doctoral dissertation. Univ. Ramon Llull.
- Serrano, L., Bosch, M., & Gascón, J. (2010). Fitting models to data: the mathematising step in the modelling process. In V. Durand-Guerrier, S. Soury-Lavergne, & F. Arzarello (Eds.), *Proceedings of CERME6* (pp. 2186–2195). Lyon: Institut National de Recherche Pédagogique and ERME.

Winsløw, C., Matheron, Y., & Mercier, A. (2013). Study and research courses as an epistemological model for didactics. *Educational Studies in Mathematics*, 83(2), 267–284.