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Cross-disciplinary Characteristics of Study and Research Paths: Statistics for Business Administration

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Statistics is a discipline that allows implementing novel teaching proposals based on inquiry. Students' reasoning in the statistical context can be encouraged by implementing project-based learning in statistics courses. Statistical processes often involve other disciplines apart from statistics itself. We present an analysis of the staging of cross-disciplinary characteristics of an inquiry-based project in statistics for the degree in Business Administration. Three moments of cross-disciplinary collaboration are described and analysed from both the viewpoint of teachers and students. Broadening the perspective beyond the domain of statistics provides us with new insights regarding student engagement, challenges related to project organisation and management, and a venue for cross-disciplinary dialogue.

Keywords: cross-disciplinarity, statistics for business, study and research path, teaching and learning of mathematics in other fields, novel approaches to teaching.

INTRODUCTION

Traditionally, statistics has been taught in a lot of different university degrees and has recently gained more prominence in numerous professional areas. The importance of information technologies is growing (Nolan & Temple Lang, 2010), and so are the proposals for training students to gain computational and statistical competencies. As a consequence of the technological development in the past decades, a large number of statistics educators have embraced pedagogical novelties in their teaching. Project-based learning (PBL) (Batanero et al., 2013) in particular has been promoted as a design tool for nurturing reasoning in a statistical context (Wild & Pfannkuch, 1999). PBL is widely present in the literature on statistics teaching (Markulin et al., 2021a), and is commonly described from the perspective of the area of statistics and more general pedagogy.

The numerous implementations of project-based proposals present different characteristics depending on the way statistical knowledge and professional activity are conceived in each institution. Several designs of so-called *study and research paths* (SRPs), framed within the Anthropological Theory of the Didactic (ATD), have been implemented in statistics, in other disciplines, and in cross-disciplinary contexts at the university level (e.g., Barquero et al., 2021). The main aim of SRPs is to support the development of student knowledge in an area of study by posing meaningful and challenging generating questions to students (Jessen, 2014). According to Barquero et

al. (2007), it is important for the generating question to be “of real interest to the students (“alive”)” (*op. cit.*, p. 2052).

Considering the recent developments both in business and in statistics, a subsequent question is: What and how to teach Business Administration students? In other words, the organisational goal of PBL and SRPs needs to be adapted to the topic and complexity of the degree in which those tools are implemented to be in line with its specificities. In the following sections, we present the ATD as the framework to analyse the modelling aspects of the proposals. We describe the implementation of SRPs in a statistics course for a degree in Business Administration and explore some issues regarding cross-disciplinary collaboration when designing and implementing an SRP, and how it is perceived by the students.

THEORETICAL FRAMEWORK

Within the field of mathematical modelling, a dominant approach to its teaching and learning is modelling when addressing a real-world problem, transposing it to the realm of mathematics, and addressing the mathematical problem before moving it back to the real world validating the result found in the process (Niss & Blum, 2020). However, this approach might not capture important aspects of the real modelling activity, as it takes place in the workplace (Frejd & Bergsten, 2016). Some of these aspects were analysed in a study by Serrano et al. (2010). The authors argued that the SRP implemented on the sales forecast of a fashion brand shows the intertwinement of the extra-mathematical and mathematical (or statistics) domains when fitting real data and real-world problems in one-variable functions.

Initially, SRPs were proposed by Chevallard (2004) as a way to design the cross-disciplinary projects introduced into French secondary schools (Winsløw et al., 2013). An SRP is initiated by posing a generating question Q_0 to students, who consider it real (Barquero et al., 2007), and worth pursuing, though they cannot answer the question immediately (Jessen, 2017). To answer the question, they need to engage in the processes of study and research. The study process is characterised as the study of new knowledge, which the students decompose. This means they need to understand what it is made of, how it can be used, etc. During the research process, the students reconstruct the new knowledge (in combination with existing knowledge) into partial answers to the generating question (Jessen, 2017; Winsløw et al., 2013). Furthermore, we can see this as a process where students pose derived questions Q' to the generating question, which they construct answers to through study and research processes. Thus, the generating power of Q_0 can be considered as the degree to which it invites students to pose such derived questions. Winsløw et al. (2013) depict this dynamic through a question-answer map presented in Figure 1.

When working with SRPs, the intertwinement of the domains involved in a modelling activity is reflected in going back and forth between questions and answers, between study and research. Moreover, we see this interconnection in cross-disciplinary SRPs, when an answer in one knowledge domain leads to a question in others. This can be

seen in the SRPs analysed by Jessen (2014) on mathematics and biology, where answers in biology turned into questions regarding differential equations in mathematics.

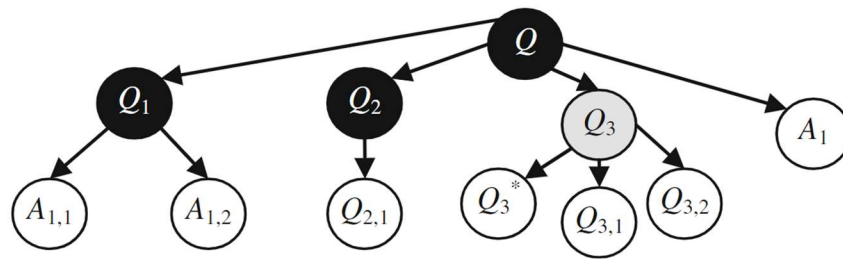


Figure 1: An example of a question-answer map (Winsløw et al., 2013, p. 271).

CONTEXT OF THE STUDY

We analyse the organisation of three SRP implementations in a statistics course in the second year of a bachelor's degree in Business Administration. Each of the implementations, during academic years 2019/20, 2020/21 and 2021/22 had its peculiarities concerning the topic of the project, the scope of the data to be gathered and analysed by the students, and the logistics of the implementation modality due to the COVID19 restrictions. However, the characteristics common to all the implementations were the collaboration with researchers in marketing, the existence of a “client” that was the facilitator of the project topic, and students organised in teams of 4-5 members acting as consultants for the client. More about the topics and the SRP implementations can be found in Markulin et al. (2021b, 2022a, 2022b).

RESEARCH QUESTION AND METHODOLOGY

Our work contributes to broadening the scope of SRPs in the domain of statistics in a Business Administration school by analysing constraints and conditions seen from the perspective of students on cross-disciplinary projects. The SRPs presented are implemented in a statistics course, although they could be implemented in other disciplines, encouraging different perspectives from which a certain project can be conceived. In this respect, we formulate our research question (RQ):

RQ: How can cross-disciplinary collaboration foster the management of a project in a statistics course in a Business Administration degree?

We will consider the issue from the macro-didactic perspective by analysing the collaboration of statistics lecturers and students, researchers in marketing, and external clients that are not usually involved in the education system. The approach we take is a qualitative analysis based on post-project interviews with the students. We comment on the experience of the project implementation, and finally, contrast it with the statistics students' reflections on the cross-disciplinary characteristics of the SRPs.

The post-project communication with the students is organised as semi-structured interviews, designed by a statistics teacher that also assumes a position as a researcher in didactics, together with five or six students. The students who participate in the

interviews represent the students' working teams that participated moderately or actively in the project (according to the teacher's perspective and the students' final grades in the statistics course). The interviews are approximately 30-40 minutes long and structured according to the hypotheses on the SRP development put forward by the teacher-researcher in didactics. As shown below, the interviews are structured in such a way that broader problematic issues than simply the research question of the SRP addressed in this paper are analysed. The hypotheses (H) behind the interview script consider the:

H1. *Generating question and project aim.* The project comes from an external client who also presents the topic to the students. The generating question is a problem to be solved by student teams and is presented to an assessment jury at the end of the project to add realism to the project. An issue to discuss is the pertinence of the generating question, its driving force throughout the inquiry, and the extent to which the final answer presented by the students provides valuable information to the client.

H2. *Project survey and data collection.* The design of the project survey that students use for data gathering, the understanding of its components and its use to provide meaningful data to be analysed takes place in the interaction between statistics, marketing and the client's needs and possibilities. The interest in discussing its components is threefold: describing the students' involvement in the design part of the survey; the adoption of its *raison d'être* that fosters the arborescence of the derived questions to be statistically analysed; the insight into the challenges that students encounter when collecting data and the solutions they propose or implement to overcome the obstacles in such a "rudimentary" activity of collecting raw data and cleansing it before the statistical analysis. This is not usually part of a project students would expect in a statistics course but is essential for the profession of statistics.

H3. *Integration of the SRP in the statistics course.* The SRP is part of the statistics course, but the course is organised for the SRP to be its central activity. The classes preceding the project are organised in bi-weekly (14 days long) case studies or topic-related exercises that prepare the ground for the SRP to be implemented. The main issue of this section is the students' perspective on the integration of the SRP into the structure of the course. The connection between the bi-weekly studies and the project can be appreciated by recognising the importance of the provided software tools and knowledge for the project work, inquiry strategies developed before or during the project, cleansing the data, raising questions and synthesising results.

H4. *SRP organisation and management.* The SRP implementation during the statistics course, its development in student teams, the submission of the students' intermediate analyses reports, and the students' presentation of the final results as a poster or a slide show in front of the entire class are the organisational characteristics that are the most closely connected to pedagogical and school interventions.

A more detailed description of the interview design and the hypotheses supporting the script are described in Markulin et al. (2021b, 2022a).

Even though the different SRPs were implemented in the classroom under the guidance of the statistics teachers only, they were prepared thanks to the cross-disciplinary collaboration mentioned earlier. After analysing the students' interviews and identifying indications related to cross-disciplinary issues, especially concerning the first two hypotheses mentioned above, we present three moments in which collaboration is key:

- 1) agreement with the client,
- 2) design of the survey for data analysis,
- 3) understanding and exploiting the survey.

SRP EXPERIENCE AND DISCUSSION

The first moment: agreement with the client

Once a client willing to collaborate on the project is found, chronologically, the first step is to explore the potential of the problem's generating question. Figure 2 is an example of a statistics teacher's a priori test of a potential topic for the third SRP implementation. It can either be developed visually in a question-answer map (we tend to include only the questions in this kind of map, while the answers remain implied), or elaborated as a list of topics that can be derived from the initial generating question.

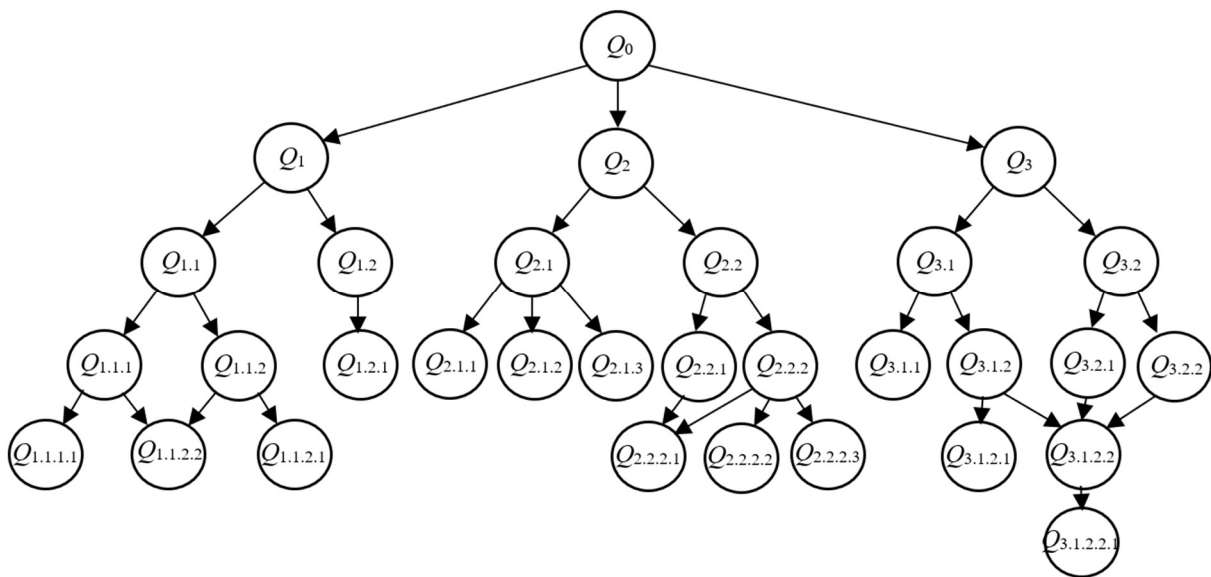


Figure 2: A priori question-answer map for the third SRP implementation

The generating question is Q_0 : “What are the consumer habits and preferences of young people in Spain about sustainability, digitalisation, and leisure time?” The derived questions focus on sustainability issues (Q_1), experiences with digital services (Q_2), and leisure-time habits (Q_3). We will not go into detail about the map components in Figure 2, since it is not the focus of this paper, but the full text of the questions can be found at <https://rb.gy/uzez4y>. We will consider the moments based on collaboration. The first one is the final agreement with the client. It is worthy of note that, even at this early stage, the statistics teacher tends to leave the boundaries of the discipline to embrace the context of the potential data (something the students will eventually do as

well once they start inquiring about the matter). The planning of the project development and its main focuses take place at the same time as the agreement with the client. Then, some of the SRPs trajectories proposed by the teacher are discarded, while new ones gain importance. This teacher-client communication is a pre-test of the communication that the client will later have with the different student teams. This interaction leads to improvements in the a priori analysis and adjustments are made to the teaching design, hence changing the focus of the data analysis at a later stage of the project. Moreover, this makes the situation more akin to genuine business practices.

The topic of the first SRP was vegetarian and vegan diets. Students found it interesting but were not very familiar with it. An illustrative example of this distance from the topic is the statement of one of the students:

Student A: The topic is actually really good and interesting and the things we could see were really interesting, but it affects just a small group of people.

The second implementation concerned an SRP on a less restricted population, but it was locally oriented and about an initiative, the students did not know well – a cooperative supermarket looking for its optimal first location in Barcelona. The statement of one of the students reveals this fact:

Student B: I think it was an interesting topic, different from what is normally dealt with in some projects by better-known brands or companies... I think it's a way that helped us to do a bit of market research, which, in the short term, will be something that we will have to do.

The third implementation was a collaboration with the marketing department of an international company about the attitude of young people in Spain towards sustainability. Thanks to the experiences from previous years, the interaction between the client and the students were given more importance in this implementation. Apart from the client presenting the project topic and ideas, an additional online meeting session with the client was scheduled. During that session, each student team met with the client. The students abandoned their role of “students” and adopted a more professional attitude. This was observed especially in those student teams that abandoned some of their initial problem proposals and redirected their inquiry adjusting it to the client’s needs.

Student C: At the meeting with the client, we presented our team’s ideas on which to focus our analyses during the project. However, she told us to pursue certain ideas we presented, but also to discard some of them. We realised that not everything we proposed was interesting to her. We continued the analysis based on what the client suggested.

In the implementations where such interaction between students and the client during the project development was not possible to organise, the students sometimes tended to support what they considered to be the teacher’s proposal at the expense of what was relevant to the client.

The second moment: design of the survey for data analysis

The second stage that requires collaboration outside the area of statistics is the design of a survey that will be used to gather the data for the project. It is a delicate moment since its production will directly affect the students' work and potentially create extreme actions, as we will show in the discussion on the impact of the collaboration of the third moment. Here, the statistics teacher teams up with researchers in marketing at the same business school. This collaboration is beneficial to both sides: the statistics teacher ensures the data to be gathered using the survey will suffice for the project's goal; the researchers in marketing get involved in a study in their area of interest and possibly enlarge their contribution to marketing research literature based on the ideas and results obtained from the Statistics project.

In the SRP implementations presented in this paper, most of the survey design responsibility was assumed by the researchers in marketing. They engaged in the survey design in teams. The teams differ slightly every year but mostly consist of one experienced researcher and two young researchers (PhD candidates at the business school where the Statistics course and SRPs took place). In the first SRP implementation, the survey was completely done by the marketing experts, since they were the initial "client". In the second implementation, the survey was designed in collaboration with researchers in marketing, the client, and the statistics teachers. In the third implementation, the survey was the final product of the collaboration between everyone involved in the project: researchers in marketing, the client, statistics teachers, and the students.

However, in the second implementation, when there was a chance to engage more with the client who posed the generating problem, the students hesitated to take part in the survey design. The following statement of one of the students shows that designing the survey might cause a feeling of uncertainty.

Student D: If you had asked me to do it [design the survey] at the beginning or in the middle of the course, maybe I would have posed questions that at the end would be of little use for my analysis.

It seems the students lack knowledge, or confidence, to master the task of developing a survey to be statistically exploited. It is a challenge to statistically model a problem from the marketing domain. Collaboration with the researchers in marketing is, therefore, necessary and supportive for both students and statistics teachers.

The third moment: understanding and exploiting the survey

Students are the ultimate "miners" of the project survey. They are supposed to collect the data, clean them, and analyse them. Those actions are very common in contemporary business environments, in data science laboratories, and even in numerous professions remotely relying on statistics. However, most of the PBL literature focuses on competencies in data analysis and does not question the origin of the data and the cleansing process (Markulin, 2021a). In the SRPs here presented, the

data origin appears to have stimulated even some lower achieving students to engage in the project, as student E states:

Student E: ...for the first time I think we have been able to work and contribute to a project that has not only been an ordinary task, but a real case...we realised that our work could provide something to the client.

According to the students' comments from the first two SRP implementations, the external origin of the survey caused certain detachment, even for high achieving students, such as Student F. Some radically stated that it would have been more useful if they could have used their own surveys (Student G), which might also be a sign of difficulties in recognising the relevance of the data coming from an external survey.

Student F: I think the survey was super long. That's why I suppose we couldn't analyse everything.

Student G: If we could start from the beginning and ask the questions that we want to answer from our data, it would have been clearer and more realistic.

Nonetheless, the process of cleansing and analysing the data eventually allowed the students to become familiar with the survey blocks and to start appreciating the design they were asked to follow. Student A describes this progressive process as follows:

Student A: For example, when we got the answers and we started analysing the data, we saw that the survey was even clearer than we thought because there were correlations [between the answers to different questions in the survey].

It appears that the inclusion of external clients and survey facilitators represents both a productive condition and a challenging constraint for the students. In any case, this kind of organisation is the closest to a business environment that the teachers could have organised in a university setting under given conditions.

CONCLUSIONS

As shown in the previous section, the three phases involving the design and implementation of the SRP (agreement with the client, survey design and survey exploitation) lead to different levels of cross-disciplinary collaboration. Firstly, the existence of an external client generates two significant interactions, one between statistics teachers and the client in the first steps of the SRP, but also between the client and statistics students. As stressed earlier, the existence of a real client fostered the engagement of the teams. This phenomenon is already described in terms of *adidacticity* of the SRP by Barquero et al. (2021). It concerns observations on how the existence of an external client can favour the conditions under which the development of a final answer becomes the central activity during an SRP (Bosch et al., 2023). Consequently, there is a shift of the main purpose of the activity from the academic aspects such as course evaluation towards the production of reports for the clients.

Secondly, the interaction between marketing researchers and statistics teachers helps overcome the so-called *thematic confinement* (Barbé, Bosch, Espinoza & Gascón,

2005), that often exists in school institutions. However, this cross-disciplinary collaboration is still limited: marketing researchers that are also teachers in the same institution do not incorporate the survey design in their teaching activity. This reveals a clear restriction at the pedagogical level: the SRP is only implemented in one course. We think that an open issue of this research is related to the analysis of the restrictions hindering these cross-course collaborations to explore the ecological viability of cross-disciplinary SRPs.

Finally, the existence of different actors involved in the SRP design and implementation is an important challenge. The interactions between students, researchers, clients, and teachers need to be organised during the a priori and in vivo analysis of the SRP. This is often a new activity for lecturers that might find institutional tools to enable collaboration.

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