CHALLENGES IN THE PLANNING OF STATISTICAL PROJECTS FROM AN INTERDISCIPLINARY PERSPECTIVE: A DIDACTIC EXPERIENCE

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We report the challenges four educators from different disciplines faced while planning a statistical project as a didactic strategy to promote interdisciplinarity. The study was framed in a nine-stage interdisciplinary system: inputs, group statism, relational game, decision game, dynamic game, dynamic-relational game, dynamic-relational-situational game, product, and new expectation. This system allowed us to identify the most challenging stages in the planning of statistical projects through an interdisciplinary approach. Though we recognize statistical projects can foster interdisciplinarity, this issue is difficult to address in real-time teaching practice. Our study shows the main difficulties lie in identifying real problems whose solution requires integrating distinct disciplines.

INTRODUCTION

The interdisciplinary approach emerged in the 1970s to promote integrating knowledge from distinct disciplines (Berridy & Fernández Guillermet, 2021). Some universities in Mexico undertook reforms to encourage interdisciplinarity through integrated curriculum design that views "problem-based or project-based learning as a didactic technique [that stimulates] collaborative learning to study specific problems systemically" (Villa Soto & Mendoza Rosas, 2020, p. 178). Through the government-sponsored New Mexican School project, the country's current educational system (implemented PK-12) promotes learning linked to students' reality by solving problems related to their social contexts. For teachers, this demands didactic, collaborative work with their peers to "develop multidisciplinary, interdisciplinary and transversal work" (Subsecretaría de Educación Media Superior, 2023, p. 20). As Lenoir (2013) observed, however, "It is not enough to just use words to implement things!" (p. 52). Instead, an interpretative, operational stance of interdisciplinarity aligned with the educational project one aspires to conduct is required.

Educational proposals must recognize that, in practice, interdisciplinarity is challenging (Groves et al., 2017), for this is a polysemic term with distinct meanings that can confuse teachers' discourses and affect their teaching practice (Lenoir, 2013). Moreover, school practice often offers little curricular integration among courses (e.g., mathematics, biology, chemistry, physics), since they are approached with distinct intentionalities (Roth, 2020). Teachers can only be expected to know, or understand, links among disciplines if those connections are explicit and based on curriculum development projects (Williams et al., 2016).

Lenoir (2013) pointed out one necessary condition for applying interdisciplinarity in education consists of adopting pre-planned interdisciplinary pedagogical models. In the field of mathematics education, interdisciplinary work has emerged primarily under the STEM or STE[A]M approaches (Williams et al., 2016). The role of statistics in supporting decision-making, particularly based on data collected in these disciplinary fields, is significant since statisticians have the unique opportunity to explore various fields (Watson et al., 2020). As John Tukey famously put this, "you get to play in everybody else's backyard". Although other interdisciplinary pedagogical models, such as problem-based and project-based learning, have been studied extensively due to their capacity to promote inquiry, collaboration, and the application of disciplinary content (Brassler & Dettmers, 2017), recognition of Statistical Projects (SP) as an interdisciplinary strategy (Bertorello et al., 2020; González Correa et al., 2010; Kuiper, 2010) is a promising, but underexplored, area. Additional research is needed to fully understand their potential and the challenges they present in establishing interdisciplinary links.

This article analyzes the work of Mexican educators from distinct disciplines as they planned a SP. Our goal was to elucidate the challenges they faced as a contribution to the study of interdisciplinarity from a functional perspective based on designing pedagogical models. As Lenoir (2013) stated, the problems of managing interdisciplinarity are the primary obstacles involved in implementing it in the classroom.

In: Kaplan, J. & Luebke, K. (Ed.) (2024). *Connecting data and people for inclusive statistics and data science education. Proceedings of the Roundtable conference of the International Association for Statistics Education (IASE), July 2024, Auckland, New Zealand.*

FRAMEWORK

Lenoir (2013) held that interdisciplinarity offers a way to integrate learning processes and knowledge, and so ensure their mobilization and application in real situations. Interdisciplinary work emerged as an essential tool for confronting the multifaceted problems that characterize today's world, and as a way to conduct scientific research and organize the sciences (Tamayo & Tamayo, 2003). From a dynamic way of seeing and dealing with problems, Tamayo and Tamayo (2003) presented a nine-stage theoretical system of interdisciplinarity designed to integrate distinct fields effectively. Its stages are inputs, group statism, relational game, decision game, dynamic game, dynamic-relational game, dynamic-relational-situational game, product, and new expectation (Figure 1). In what follows, we analyze how the educators planned their SP from the perspective of this interdisciplinary system.

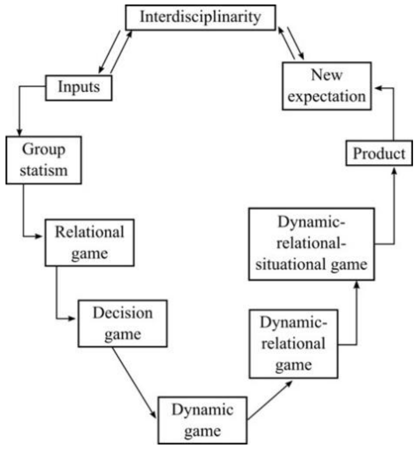

Figure 1. System of interdisciplinarity (Tamayo and Tamayo, 2003, p. 84).

- *Inputs*: a multidisciplinary group (members of different disciplines) meets to determine a situation or problem about reality that demands solutions from various fields.
- *Group statism*: lacking criteria and knowledge to address the problem of how to contribute to a solution from their discipline, members ask questions and express their concerns, disorientation, and self-consciousness.
- *Relational game*: this space for rapprochement marks the beginning of disciplinary integration, as members exchange ideas and expectations about the problem.
- *Decision game*: members discuss and determine the crucial aspects of the problem to identify, and reach a consensus on, common elements among their disciplines. This is an essential step in integrating contributions coherently and productively to move toward a solution.
- *Dynamic game*: this stage is considered 'pre-interdisciplinary' because ideas and approaches from the unique perspective of each discipline help dimensionalize the problem.
- *Dynamic-relational game*: the group seeks to overcome the differences identified previously to reach a level of convergence. It promotes the transformation of group dynamics from a collection of individual experts to a team with a unified vision and purpose.
- *Dynamic-relational-situational game*: this game is marked by team cohesion and unity of purpose. It highlights convergence toward a standard methodology and a unified approach, while allowing the formulation of appropriate methods and tools to solve the problem.
- *Product*: achieving common goals; that is, attaining group unification and solving the problem.
- *New expectations*: the continuous cycle of learning and collaboration does not end once the problem has been solved but, rather, generates a new expectation as an input that pushes the system to initiate a new research project.

Tamayo and Tamayo (2003) recognized that creating an interdisciplinary team, unifying language, and formulating a common problem are all fundamental tasks of an interdisciplinary methodology.

STUDY DESIGN

This paper is based on one part of the second author's doctoral research (Espino Flores, 2022), which was supervised by the first author. The former invited four educators from a Center for Professional Teacher Education to participate. He explained they were to plan a SP that posed a problem that could be addressed from the perspective of their respective disciplinary fields and statistics. Among other tasks in their daily workload these educators attended to the institutional needs of the Teacher Training Colleges in the state, so they seized this opportunity to experience designing a SP and incorporating it as a training strategy there. Since they volunteered to participate, no consent procedure was necessary.

Apart from their jobs in the Center, one of the educators worked as a teacher in the same Teacher Training College where they planned to implement the SP. Another was giving courses in their disciplinary area in a university. The other two worked exclusively at the Center. They indicated they had some experience in collaborative work but usually worked individually. Planning this SP was the first collaborative work that involved all four. Their training was in the disciplinary areas of Arts, Physics, Biology, and Pedagogy/Mathematics, so we refer to them as A, P, B, and PM. Their respective years of teaching experience were 7, 9, 22, and 40. In Mexico, statistics courses are normally taught by mathematics teachers because there is no specific training for statistics. The second author joined the educators as a collaborator (C) to provide support on issues related to statistics education. As a participant observer, he intervened in the educators' discussions as required to aid in statistical design and content aspects since he is knowledgeable in the area of SP.

Data collection and processing

Data were from the video recordings of 21 planning sessions held from January to April 2019, each one of approximately two hours duration. Our approach was qualitative. The data reflected the educators' opinions, decisions, and agreements, among other comments (de Freitas et al., 2017), all taken from their discussions of topics related to planning their SP. Data processing was based on the following qualitative techniques: classifying the video recordings in chronological order (by session), transcribing their content, identifying participants' opinions and ideas, and coding (Alvarez-Gayou Jurgenson, 2013). We processed approximately 42 hours, 49 minutes of recordings. All transcriptions were written in dialogue format and sectioned according to the distinct topics the educators addressed in each session. For each session, we identified issues related to curricular, didactic, pedagogical, and disciplinary knowledge and processes. Participants often addressed several topics but sometimes left some topics unfinished to deepen their study of aspects they deemed necessary. Despite the broad range of issues broached, three major themes were identified and marked as Episodes 1, 2, and 3. For each episode, discourses were analyzed according to the stages of the interdisciplinary system shown in Figure 1. Due to space limitations, the discussions presented are not exhaustive.

RESULTS

Episode 1. Search for the purpose of the statistical project

The problem that brought this group together was to plan an interdisciplinary SP that would integrate knowledge and processes from their disciplines to be implemented as a teaching-learning strategy in the training of future mathematics teachers (hereafter, "students") in Teacher Training Colleges. Planning consisted of formulating an investigative problem, which served as the *input* that initiated the interdisciplinary system. The educators' early discussions revolved around understanding the curricular, didactic, and pedagogical features of the SP. That commenced the stage of *group statism* in which participants raised concerns about the didactic purpose of the SP in terms of satisfying the training needs of students, but came to perceive it would allow their pupils to develop skills in using statistics to solve real problems.

A: *Developing skills using statistics to solve real problems for pedagogical purposes* [is] *an objective focused on the needs of students with bachelor's degrees in mathematics education.*

Participants also thought the SP offered the opportunity to do research using statistics, and proposed organizing a workshop to address the demands of the existing curriculum: transversality, mathematical training, linking school and life, and training in conducting research.

A: *We'll give this generation, starting with the new mathematics curriculum, their first introduction to research… research with statistics.*

PM: *That workshop should aim… first, at transversality, second at mathematical disciplinary training, third at the link between school and life,* [then] *mathematics for life…*

A: *And… number four is training in doing research.*

Another curricular issue they considered was incorporating the SP into a course entitled "Information Processing". As they explored that possibility, PM brought up the issue of the difference between information and data.

PM:*… I'm in a dilemma because the subject is called information processing… but information is one thing, data is another…*

This pushed the educators into a state of confusion and disorientation. They had never taught a course on statistics in the Teacher Training Colleges, and were now trying to understand the content of the "Information Processing" course and how they could implement the SP into it. Mathematics teachers usually teach the course, and PM was about to introduce such course. Since the educators were grappling with the challenge of incorporating the SP into the study program, a sense of *group statism* emerged. After some clarifications about "information" and "data", B tried to explain how treating information was related to a problem they would address from their disciplinary areas, using statistics.

B: *We're giving them information about a problem… How do I provide a solution* [to it] *from the environmental and educational points of view?… When you deal with that information, statistics come into play.*

B's explanation marked the entry into the *relational game* stage because a first idea of rapprochement among the disciplines emerged. For the first time, a problem was suggested that could be studied from their disciplinary knowledge using statistics. B mentioned approaching this problem from environmental (referring to the disciplinary area of Biology) and educational perspectives (Pedagogy). Before determining the problem precisely, they discussed some aspects of the statistical content that the SP might require (*decision game*), especially basic content. C took the opportunity to remind members that the specific statistical topics required would depend on the problem.

A: *The minimum statistics necessary, but we still need to define what they are.*

C:*… We need to define the project first in order to determine what statistics we'll need.*

Thinking about, and discussing, statistical content is a feature of teachers' pedagogical knowledge. In this case, they knew that most students had a poor understanding of statistics, so they warned that the SP could involve only basic knowledge of the field. That knowledge, however, also depended on the general problem and the specific aspect of it that they would eventually select.

Episode 2. Searching for the problem for the statistical project

B was the first to propose a possible problem: school performance. That led to a discussion on how they could study that topic from their disciplines (*relational game*).

B:*…I can think of one* [a problem] *of health, nutrition, and focus it on…* [students' school performance]*…but maybe they say* [referring to her colleagues]*…I'm interested in the environmental issue, and then he* [P] *focuses on it and, maybe A* [says]*… I'm interested in the creativity part…*

P: *Yes… that's fine with me. The detail is to find a problem that encompasses all areas… It's a matter of thinking about it and discussing it.*

B offered an idea of how A, P, and B could study school performance using their disciplinary knowledge. For example, B considered school performance from a health and nutrition perspective but clarified that her colleagues could approach it through environmental aspects or creativity. In subsequent discussions, they made a joint evaluation to determine the characteristics that the problem had to fulfill (*dynamic game*): it had to be (1) a real problem that was (2) relevant to the students, (3) "multifaceted" (multidisciplinary), (4) solvable through statistical treatment, and (5) feasible.

A:*… The fundamental condition*[s are] *that* [the problem] *has to be approachable from statistics… that [it's] real… that [it's] relevant to* [the students]. *What else?*

PM: *Multidisciplinary.*

A:*… Different aspects… multifaceted.*

P:*… Be viable for* [the students]. *We might find one that's very good but out of their reach.*

Subsequently, C took up B's proposal on nutrition to propose designing an instrument to collect data. That idea allowed the group to advance in their proposal to select school performance as the SP problem.

C:*… I think students would first have to document, on their own, what good nutrition is, and then generate the instrument.*

A: *I would work with a cultural consumption survey. The Ministry of Culture has applied one at the national level, and the* [students] [could] *determine which items and components are relevant, then adapt them.*

At that point, A proposed verifying whether some questions from the cultural consumption survey could be related to students' school performance. The initial idea was that participants would select the questions and construct the instrument. The educators also discussed how they could study school performance from the other disciplinary areas, since cultural consumption was a type of knowledge that pertained to A. To this end, P shared her experience with STEM activity –in a project to design a robotic arm– to help understand how the disciplines that participated had been integrated. P's example led the educators to reflect on how best to incorporate the disciplines naturally and have the SP address an issue that would be congruent with their students' training.

A:*… This* [robotic arm] *problem is relevant to an engineering student. What could be, or where would a relevant project for a mathematics education student have to go?…*

Participants returned to their initial proposal of school performance, but this time raised the possibility of investigating a relationship with nutrition, cultural consumption, and weather [seasonal temperatures]. In addition, for the first time an idea about the data they would use to represent that performance emerged, namely, students' grades.

A:*… nutrition… is there any correlation between students' achievement levels and eating habits?… for the Arts area… see if there's a correlation between their cultural consumption practices… and… their achievement levels…*

P:*… in terms of weather… see how temperature affects student achievement, see if in May-June* [the hot season] *grades drop, things like that.*

The educators were increasingly visualizing how best to integrate statistical knowledge (data, correlations) with their disciplinary knowledge, but still did not manage to converge on a more integrative idea of their disciplinary knowledge and processes to address the problem of school performance (another example of *group statism*). Instead, their concerns focused on didactic and pedagogical issues. For example, to help them concretize the SP, C recommended some research articles that exemplified, on the one hand, disciplinary integration during the development of the SP and, on the other, the stages of development of a SP. Reading one of those articles prompted reflections on whether the students should raise the problem, or if the educators should propose it. On that point, PM emphasized the complexity of working on real problems in the classroom.

PM:*… there are two problems, two types of problems: the real problem and the didactic problem. I have often seen a tendency to state that "you are bringing real-life problems into the classroom"… but what happens? No problem is real; it's doubtful you'll find a real problem that meets all the didactic requirements. So, sometimes you must collect, let's say, twenty, thirty real problems and condense them into one… reach a level of abstraction from the twenty real problems to build one…*

In this excerpt, PM explained the difficulty of bringing real problems into the classroom, since this requires a process of abstracting from the reality of the problem because not all the factors that influence it can be considered. This process demands synthesizing reality in order to make the problem operative in the classroom; that is, converting a "real problem" into what he called a "didactic problem".

Reading the articles also helped the educators realize the importance of posing a research question. Two of their proposals were:

B:*… What pedagogical factors influence students' grades?*

A:*… Pedagogical factors* [related to] *nutrition, cultural consumption, and temperature…*

Educator A referred to student achievement as a pedagogical factor. Although the research question incorporates aspects of the educators' disciplinary areas, the cooperative links needed to answer had not yet been, so we could say that they had reached a pre-interdisciplinary stage (*dynamic game*).

Episode 3. Determining the problem of the statistical project

The educators and C met with the latter's thesis supervisor to share their progress in planning the SP. During that discussion, the supervisor asked them if the problem of school performance was a real one in the institutions where they worked. That question stimulated the educators' desire to learn more about the real problems they faced at school; hence, PM proposed consulting the institution's Director:

PM: *I propose… we make an appointment with* [the Director's surname] *and his people, say… we need them to tell us which problems affect them the most…*

During that visit, the Director and other faculty members brought some of the problems they were experiencing to the educators' attention. The educators subsequently met to discuss those issues and determine the one they would study through their SP.

B:*… What's the problem going to be?…* [At the institution] *they have two problems: failures and dropout rate… Why do they have dropouts? Or why do they have failures?…*

A: *In general, they have a real academic problem: failures, desertions, and a lack of academic culture…*

Taking up one of the problems the institution's academic staff expressed, the educators once again discussed the context, but now evaluated the aspects of the problems raised by the academic staff to decide which one to select, and how to handle it from their disciplines. This brought them back to a *decision game*. After exchanging opinions on how they could best address various problems from their disciplines, they chose one they called "academic culture".

The experience gained in the prior planning sessions helped establish criteria for approaching this problem from their disciplinary areas (*dynamic game*), since they maintained the idea of integrating knowledge from Biology, Arts, Physics, and Statistics to study the problem. They also considered using an instrument to measure "academic culture". PM recommended an article that outlined some indicators used to measure an institution's quality of education (Castillo Riquelme and Escalona Bustos, 2016). Then the educators jointly evaluated those indicators (*dynamic game*), analyzed them, and identified those that could serve "as is", others that could be adapted, and some that did not need to be considered to achieve the shared goal of integrating their disciplines to address the problem (*dynamic-relational game*). B, for example, identified that the indicators of "healthy living habits" described in the article were related to her disciplinary area; similarly, A identified with elements that concerned "participation and citizenship training".

Determining the indicators to be used, and creating others (to integrate P's disciplinary area), encouraged participants to design an instrument that could help integrate their disciplines to approach the problem (*dynamic-relational-situational game*). The final instrument was organized in four dimensions: vocation (career choice, notions, expectations within the profession), healthy habits (physical activity, nutrition, sexuality), environmental stress (equipment, physical environments), and identity and citizen participation (identification toward, and perception of, the institution, decision-making, participation). Each indicator was accompanied by questions that –except for those on vocation– were adapted from the ones proposed in Castillo Riquelme and Escalona Bustos (2016) and Hernández Barreda and Gómez Amador (2007). The educators formulated their own questions on the aspect of vocation.

The resulting instrument showed the educators had achieved their shared goal (*product*). It reified the planning of the SP and represented the integration of their disciplinary areas to address the problem they defined. We do not analyze the subsequent implementation of the SP in this paper, but it represents the *new expectation*. Introducing the SP into the classroom and putting it into practice with students is a response to all the expectations the educators planned as they designed the SP, which would result in initiating the interdisciplinary system and working through it with students.

CONCLUSIONS

We presented an overview of the challenges a group of educators faced while planning a SP to promote interdisciplinarity. Designing the SP was the problem that brought the educators together as a multidisciplinary group. One of the most significant challenges for participants was determining the problem to be investigated through their SP, for this entailed not only finding a real phenomenon to address from their disciplinary knowledge, but also assessing its relevance to student training and the feasibility of carrying it out in the classroom, since the planning would demand considerable time (it took these educators 21 sessions to complete their planning) they do not normally have in their daily practice.

As the formulation of the problem became more precise, transit through the nine stages of the interdisciplinary system was more fluid, though not always linear, as the educators sometimes backtracked to an earlier step. The present study thus highlights: 1) the strategic aspect of defining a problem because it allowed each member of the interdisciplinary group to contribute from their disciplinary point of view; and 2) the need for curricular support for teachers, who will require problems that exemplify how integrating various disciplines can foster interdisciplinarity in their schools. Equally important, the teachers will need the support of various individuals and several kinds of resources to guide them. In the present study, the support of C and the articles the educators reviewed played crucial roles in helping them approach the SP and integrate their disciplines.

Despite the challenges outlined herein, we conclude that SP planning can be an effective strategy for organizing interdisciplinary work, as we identified two key features that acted as integrating elements: first, a clearly defined research problem, and second, creating instruments for data collection. Like the interdisciplinary system, SP are developed in order to solve, or assess, a real situation that can be studied by various disciplines, and to encourage the use and creation of data collection instruments. In this study, we observed that designing the instrument acted as an organizing axis which favored the convergence of the disciplinary knowledge of the four educators.

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