OPPORTUNITIES AND CHALLENGES IN THE IMPLEMENTATION OF A STATISTICAL PROJECT IN THE INITIAL TRAINING OF MATHEMATICS AND SCIENCE TEACHERS: REFLECTIONS FROM THE VOICE OF TEACHER EDUCATORS

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We identified opportunities and challenges during the implementation of a project in the framework of civic statistics through the analysis of the audio recording of meetings developed by the teacher educators. We highlight the project as an opportunity for the generation of interdisciplinary work in teacher training, as well as bringing the territory closer to future teachers with the development of this type of project. In terms of challenges, teacher educators find it difficult for future teachers to pose a research question that can be addressed with the available data and the difficulty of working with second-order data. We invite the generation of interdisciplinary spaces in the context of teacher training, and to move towards transdisciplinary spaces.

INTRODUCTION

The complexity of the social problems we face daily has required the efforts of different areas of knowledge to solve them. In Chile, after the curricular prioritisation following the pandemic, school education was explicitly invited to address learning objectives through joint work between different disciplines (Ministerio de Educación de Chile [MINEDUC], 2023). In particular, working across different spheres of knowledge can occur in at least three different approaches: multidisciplinary, where each discipline contributes from its knowledge to solve a problem, without the unification of a common body of knowledge; interdisciplinary, where different disciplines and approaches are brought together to understand a common phenomenon, blurring the barriers of each discipline; or transdisciplinary, where knowledge from outside the disciplines is incorporated and a common framework of knowledge is constructed that includes disciplinary and non-disciplinary knowledge (Jao & Radakovic, 2018).

On the other hand, Engel et al. (2022) highlighted the interdisciplinary nature of statistics, as it is often used in different areas of knowledge as a tool to address various issues. This aspect is even more reflected in civic statistics, as it emerges from the intersection between statistics, education and policy, and social science (ProCivicStat, 2018). Therefore, the origin of civic statistics invited us to develop statistical projects that involve knowledge, skills, and dispositions from different disciplines to understand and address social issues from different knowledge paths. From this, in Ubilla et al. (2024) we analysed Chilean curriculum documents for three subjects (Science for Citizenship, Citizenship Education, and Mathematics) based on the conceptual framework of civic statistics (Gal et al., 2022), which involves eleven facets distributed in three dimensions: Engagement and Action, Knowledge, and Enabling Processes. From this research, we have observed that interdisciplinary work can be an option to promote citizen participation, with statistics as a cross-cutting theme. Thus, we consider that this analysis and the current curricular change in Chile have repercussions on initial teacher training, as it is necessary to generate spaces that promote collaborative work between different disciplines. This scenario challenges teacher educators, as they are the ones who model educational practices for future teachers (Rojas et al., 2021).

Considering the above, we designed and implemented a statistical project in the context of the initial training of mathematics and science teachers, which allows us to address local social problems in an interdisciplinary way and to enhance the scientific and statistical knowledge and skills that enable their understanding. In this case, the interdisciplinary approach is observed in the joint work between teacher educators, who dialogue from their disciplines to generate a project with an interdisciplinary approach. So, we would like to discuss the question what are the educational challenges in teaching statistics from an interdisciplinary perspective?

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PROJECT DESIGN

Context

The University of O'Higgins (UOH) offers programs for teacher training: Pedagogy in Natural Sciences (PNS) for science teachers and Pedagogy in Mathematics (PM) for mathematics teachers. PNS has two courses related to the connection between science and citizenship, but only one course related to statistics and probability. The PM curriculum includes four courses related to statistics and probability, but no courses related to mathematics in society. This led us to consider the need to enhance the social role of statistics in the training of mathematics teachers and to promote the use of statistical data and procedures in the training of science teachers. Regarding the regional social context, we addressed the problem of drought, since the water crisis that "is currently affecting the central zone of Chile has forced the government to decree an agricultural emergency and a water shortage zone in the O'Higgins region [...] which has a rainfall deficit of nearly 75% and a snow deficit of over 70% and a retreat of glaciers of nearly 5% per year" (Secretaría Regional Ministerial de Agricultura - Región de O'Higgins, 2020, p. 8). In the following section, we present the design principles for the statistical project.

Principle's design and structure of the statistical project

Civic statistics (CS): ProCivicStat (2018) presented six recommendations for addressing civic statistics in educational contexts: (1) promoting engagement with social issues; (2) using relevant data and texts on social phenomena; 3) embracing technology that enable rich visualizations; 4) promoting the development of skills that allow for critical interpretation of data and texts; 5) assessing the ability to conduct research; 6) promoting joint work between different disciplines and stakeholders.

The investigative cycle (IC): The statistical research cycle is considered a framework for the statistical problem-solving process (Wild & Pfannkuch, 1999) and can be connected to the scientific method. Its structure is identifying a problem, generating a plan, collecting, and analysing data, and generating conclusions. Bargagliotti et al. (2020) argued there is a difference in the first stage of the statistical research process, based on whether one works with first- or second-order data: the difference is the point in the research cycle at which the statistical research question is posed.

The role of critical questions (CQ): Ubilla and Gorgorió (2022) proposed different types of questions that are present both from the role of data producers and consumers. In the latter role, they considered questions about the social construction of the data, with focus on the list of critical questions for statistical message evaluation proposed by Gal (2002). Arnold and Franklin (2021), focusing on producers of data, described the characteristics that a good statistical research question should have. On the other hand, Tena and Couso (2023) set out three dimensions that should be considered when posing research questions in the science classroom: it should be a question that focuses on the phenomena to be studied, it can have a descriptive or experimental typology, and it should be a question of an empirical and plausible nature.

The project sought to address the phenomenon of drought by using real data to understand this problem at the regional level. Therefore, the design was carried out by specialists in the area of natural sciences and statistics, in order to integrate the knowledge and perspectives of both disciplines for future teachers. In the following, we will review the methodology of this study that allowed us to identify the challenges and opportunities of this work between teacher educators from different disciplines.

METHODOLOGY

This study was based on the self-study methodology, as it focused on improving teaching practice (LaBoskey, 2004) and situated the authors as creators and researchers in teaching environments, being critical friends and documenting reflections on our practice (Lunenberg and Samaras, 2011).

Implementation

In the development of the statistics project, 12 third-year students of the Natural Sciences Pedagogy course and 23 third-year students of the Mathematics Pedagogy course took part. The project was implemented in four sessions of 90 minutes each, separately for each group of students. Each

session was conducted by three teachers: two teachers in statistics education (Francisca and Valentina) and one teacher in natural sciences (Amaira). The activities developed by the students in each of the four sessions are shown in Table 1 and the students worked in groups of 3 to 4 members. Regarding the roles of the teacher educators during the implementation of the project, Amaira and Francisca led the first and second sessions, with Amaira focused on promoting discussion around the phenomenon of drought, and both guiding the formulation of research questions. Valentina and Francisca led the third and fourth sessions when they supported the students in the process of data analysis and generation of a communication product of the process.

Table 1. Description of the project and its relation to the design principles

Phase (IC)	Activity	Description
Approach to the problem	Contextualisation of the problem (CS-1)	Brainstorming around the following questions: What is drought? When do we consider a place to be "experiencing" drought? What are the factors that influence drought? How does drought relate to climate change? To contextualise the problem at regional level, students must identify the places where they believe there is drought on a map of the O'Higgins Region.
	Research question in science and statistics (CQ)	Discussion around researchable questions from the area of science (Tena & Couso, 2023) and statistics (Arnold & Franklin, 2021). Students pose a research question.
Consideration of data	Questioning the source of data (CS-2&4, CQ)	Questioning the Climate Explorer (CR)[2] data using Ubilla and Gorgorió (2022) questions.
	Rephrasing the question (CQ)	Using a database with three locations in the region, and with data on rainfall, flow and temperatures organised according to year, month or days, students reformulated their research question based on the available data.
Data analysis	Data analysis using software (CS-3)	To carry out this analysis plan, we generated a list of YouTube videos providing guidance on the data analysis process using GoogleSheet.
Communication of the information	Questioning the results (CQ)	Students questioned altered graphics in the media using as a guide the questions posed by Gal (2002)
	Conclusions and communication (CS-5)	Students must communicate their process through a news item, poster, video capsule, vignette, or article.

Data collection

After the implementation of each session, the teacher educators from the statistics education area met and audio-recorded a discussion on the opportunities and challenges after implementing the project with each group of students. The teacher educator from the natural sciences area made a personal audio recording on the topic of opportunities and challenges. Reflection was done around the following questions: *How did we coordinate? How did we carry out what was planned? What roles did we take in the planning and implementation of the project? What did we learn from each other? If we were to do this session again, what would we change to promote better learning? What would we change to improve co-teaching?* In total, 57 minutes of audio were recorded, transcribed and then analysed by an external analyst through a content analysis, to identify the opportunities and challenges that the implementation of this statistical project presented for this group of trainers, to evaluate and improve the design of the project.

RESULTS

Following the analysis, opportunities, challenges, and suggestions for improvement were identified for the implementation of the statistics project in the context of initial teacher training for mathematics and science teachers.

Opportunities

One of the things we observed was the creation of an effective space where interdisciplinarity was practised and statistics was brought closer to the natural sciences. In fact, students from the "opposite" discipline were very eager to learn and felt comfortable in the "non-expert" position. In general, the activity allowed us to bring the concept of territory closer to the fields of mathematics and science. This concept is central to civic statistics because social phenomena are located in specific territories, so this first approach to working with this concept and eliciting students' knowledge from their territories was an important contribution to the project and to the general methodology. At the level of the teacher-educator, this space also gives the opportunity to learn how to teach in different ways and to inspire oneself.

Table 2. Opportunities identified in the implementation of the project

This type of statistical project allows...	Quote
generate interdisciplinary spaces and bring statistics closer to the natural sciences.	*It is difficult to open these spaces, and I think this activity is a good way to facilitate the dialogue between two disciplines. It is, apparently, very easy to unite mathematics with natural sciences, but in practice they maintain a distance (Amaira)*
that students show a willingness to learn from another discipline.	*The students [from the PM program] were not expected to know about the technical issues of drought, and I have the impression that this allowed them to ask many interesting questions and to dialogue with the teacher [the science teacher educator] to understand the concepts (Valentina).*
connecting students with the territory, i.e. with the reality of the territory where they live.	*For the natural sciences, the concept of territory is relatively new; it is used in social sciences. However, in the development of current natural sciences, the concept of territory is essential to understand real problems of communities* (*Amaira*).
To introduce teacher educators to other ways of teaching students and nurturing their professional practice.	*For example, [...] there was a lot of interaction with the students, and I find that this is also interesting given the context of the project, which was important to highlight the contextual knowledge that they had about the drought in this case (Francisca).*

Challenges

The main challenge was the definition of the research question by the students and how to guide this process from a teacher-educator perspective. The 'approaching the problem' phase started with a general overview of the drought problem, to be progressively linked to local drought issues. This meant that the initial research questions that the students came up with were too broad and it was complex to guide them toward a narrower and more feasible research question; it was also difficult for the students to ask research questions related to secondary data, as noted by one of the teacher educators. Time is a constant challenge for teacher educators, indeed in the first implementation it was seen as the main design problem, however, it was a much more present problem in the first implementation with PNS and was easily corrected for the second implementation with PM.

Table 3. Challenges identified in the implementation of the project

This type of statistical project challenges ...	Quote
students to pose statistical research questions that are focused and that can be addressed with the available data.	"*This introduction at the initial level makes the students want to become superheroes and it is a bit difficult to focus, although this is the territory, working with data from the territory on a smaller scale also helps us in the long term to solve problems*" (*Amaira*).
students to ask questions based on secondary data	"*Students are used to collecting data, not to starting with data*" (*Francisca*).
teacher educators to manage the process of constructing a research question by students	*"Yes, the issue of questions has been something conflictive that we also saw in science pedagogy when we implemented it and I felt that this time you said something super important that, I think, allowed them to give more clarity to the students with respect to the statistical research question or this other more general research question that they had posed, in addition to making the distinction between primary and secondary data" (Francisca)*
on the organisation of class time	*"The biggest error with PNS was the time estimation"* (*Valentina*)

Suggestion for improvement

Regarding the design of the activity, the main suggestions for improvement are related to the challenges: 1) to help students to understand that research questions can be approached from both primary and secondary data and highlight the contributions of each perspective, 2) consider differentiated time slots for each phase according to the experience of the students, for example, if working with students with less science experience and more statistical experience it is useful to allow more time for the first phase of the cycle, and 3) show to students at the beginning of the statistical project the available data to pose addressable investigative questions.

Regarding broad issues, the major suggestion is to promote and sustain the work between teacher educators from different backgrounds and invite them to participate in the statistics classroom.

CONCLUSION AND IMPLICATIONS

The purpose of this paper has been to socialise the evaluation of the statistical project implementation from the voices of teacher educators to identify what we need to change in the future implementation of this statistical project but also to identify the challenges when we work from an interdisciplinarity perspective.

The interdisciplinary nature of civic statistics invites us to address social issues by putting diverse knowledge into practice (Engel et al., 2022). The civic statistics framework, however, guides the design of teaching and learning sequences (ProCivicStat, 2018), but does not indicate how to work with other teachers when addressing these issues. Creating spaces for interdisciplinary work is challenging. Currently, it is difficult for a person to know (how to teach) statistics and at the same time have a deep understanding of social and/or environmental issues. Therefore, this challenge creates the opportunity for collaborative work between teachers from different disciplines, from the design of a teaching proposal to the implementation and evaluation of that proposal. Moreover, from our role as teacher educators, it is essential to show future teachers collaborative educational practices between different disciplines (Rojas et al., 2021) so that in the future they can apply them in their educational contexts.

A relevant aspect that emerged from our analysis is the concept of territory. The project we designed involves a phase of approximation to the problem during which students draw on their experience of the problem of drought to understand this phenomenon. However, we note that this type of activity could allow future teachers to connect with their territory, broadening their body of

knowledge about a social problem. This connection would allow the transition of civic statistics from an interdisciplinary to a transdisciplinary perspective (Jao & Radakovic, 2018).

One of the limitations of our study is that we only collected information from the trainers after the implementation of the classes. Our proposal, in future work among colleagues from different disciplines, would be to collect data at times such as meetings to coordinate the design of an interdisciplinary activity. It is possible that in these moments of coordination, we could identify tensions in decision-making about the role of each discipline in this type of activity.

Finally, in our context, future mathematics teachers have had few opportunities in their training to address environmental issues, while future science teachers have had few opportunities to work with statistics. In addition to these considerations for the design of projects in the framework of civic statistics, we consider that it can be an opportunity for collaborative work between students from different careers. We hope in the future to invite other teacher educators to generate spaces for multi/inter/transdisciplinary work in initial teacher education.

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