

## Connecting statistics education and sustainability: beliefs of Primary Education teachers

*Conectando la educación estadística y la sostenibilidad: creencias del  
profesorado de Educación Primaria*

Claudia Vásquez @ <sup>1</sup>, María José Seckel @ <sup>2</sup>, Francisco Rojas @ <sup>3</sup>

<sup>1</sup> Pontificia Universidad Católica de Chile (Chile)

<sup>2</sup> Universidad Católica de la Santísima Concepción (Chile)

<sup>3</sup> Universidad Autónoma de Barcelona (Spain)

**Abstract** ∞ Currently, teachers are being challenged to integrate sustainability into school classrooms in various disciplines, and the statistics education is not immune to this trend. Against this backdrop, in this work we investigate the belief system of 11 Chilean primary education teachers who are active in statistics education and its links with sustainability. To this end, we conducted semi-structured interviews and analyzed them using a qualitative methodology under an interpretive approach. The results show that teachers acknowledge the integration of statistics education and sustainability as a challenge, identifying as the most recurring topics their mastery of content and the development of skills.

**Keywords** ∞ Beliefs; Education for sustainable development; Primary education; Statistics education; Teacher training

**Resumen** ∞ Actualmente, el profesorado se encuentra desafiado a integrar la sostenibilidad en el aula escolar en las distintas disciplinas, y la enseñanza de la estadística no es ajena a este reto. En este contexto, en este trabajo indagamos en el sistema de creencias de 11 profesores chilenos de educación primaria en activo en torno a la educación estadística y sus vínculos con la sostenibilidad. Para ello, se realizaron entrevistas semiestructuradas analizadas bajo una metodología cualitativa bajo un enfoque interpretativo. Los resultados muestran que el profesorado reconoce a la integración de la educación estadística y sostenibilidad como un desafío, resaltando como los tópicos más recurrentes su dominio de los contenidos y el desarrollo de competencias.

**Palabras clave** ∞ Creencias; Educación para el desarrollo sostenible; Educación primaria; Educación estadística; Formación del profesorado

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## 1. INTRODUCTION

The roots of Education for Sustainable Development (ESD) date back to 1987, when the Brundtland Report of the World Commission on Environment and Development was published. Since then, there have been numerous calls worldwide to promote the integration of ESD at different educational levels. In this context, as stated in the Aichi-Nagoya Declaration at the World Conference on Education for Sustainable Development (UNESCO, 2014), teachers, as an agent of social change, play a crucial role in promoting ESD. In fact, teachers today are being challenged to re-think education in different disciplines and at all educational levels in order to change the way we relate to our environment and the world. In this regard, according to Tilbury (2011), a key aspect is promoting an interdisciplinary approach that encourages the participation of students because the challenge of promoting an ESD, “is not only to integrate content such as climate change, poverty and sustainable consumption [...] but also to create interactive and student-centered teaching and learning contexts” (UNESCO, 2017, p. 7). In this regard, the United Nations General Assembly recognizes three major areas of action: economic, social and environmental, which provide the basis for the 17 Sustainable Development Goals (SDGs) (UNESCO, 2017) that cover a wide variety of topics that challenge us to have a holistic, inclusive and transformative education system.

Therefore, to promote ESD, a key aspect is the development of sustainability competencies (systems thinking competency; anticipatory competency; normative competency; strategic competency; collaboration competency; critical thinking competency; self-awareness competency; and integrated problem-solving competency). These are expected to “empower individuals to reflect on their own actions, taking into account their current and future social, cultural, economic and environmental impacts, from a local and a global perspective” (UNESCO, 2017, p. 7).

Faced with this challenge, Mathematical Education in general and Statistics Education in particular have enormous potential, since “ESD in mathematics education can lead the sustainable development movement by providing appropriate content that allows students to acquire the skills needed to understand the concepts related to sustainable development and the aspects of the world around them” (Li & Tsai, 2021, p. 2537). It is therefore important to focus not only on public policies, but also on educational programs, curriculum guidelines for the various levels, textbooks, etc., as these are key elements in advancing the development of a sustainability-oriented education system. The foregoing shows the need to pay attention to how in-service teachers envision the connecting of statistics education and sustainability.

It is in this context that this study was conducted, whose general goal is to analyze the belief systems of 11 Chilean primary education teachers around statistics education and its links with sustainability, in order to contrast them with their teaching practices in the future. We approach this study from the position of Gómez-Chacón et al. (2006), for whom a belief is never held independently of others, which is why we usually talk about belief systems and not isolated beliefs; it is

not a sum or juxtaposition of beliefs, but an organized network; that determine and influence the practice of teachers in different ways.

Therefore, through this study we seek to offer inputs to investigate the beliefs of teachers with regard to the statistics education and its links to sustainability. For in future studies to providing guidelines for designing didactic proposals that can be used to connecting statistical education and sustainability into teacher training.

## 2. BACKGROUND AND THEORETICAL PERSPECTIVE

The integration of sustainability in school classrooms and in teacher training at different educational levels has started gaining ground in recent years (Laurie et al., 2016). However, even though teachers are aware of the transformative impact of their teaching practices, in many cases, they are perceived as lacking the skills to successfully address the socio-educational challenge of integrating sustainability into school classrooms (Dahl, 2019). Therefore, it is important to explore (prior to the training processes) the knowledge, beliefs and skills of teachers involving ESD, especially in mathematics, since these teachers could be less aware of their competencies to implement education in this area (Uitto & Saloranta, 2017).

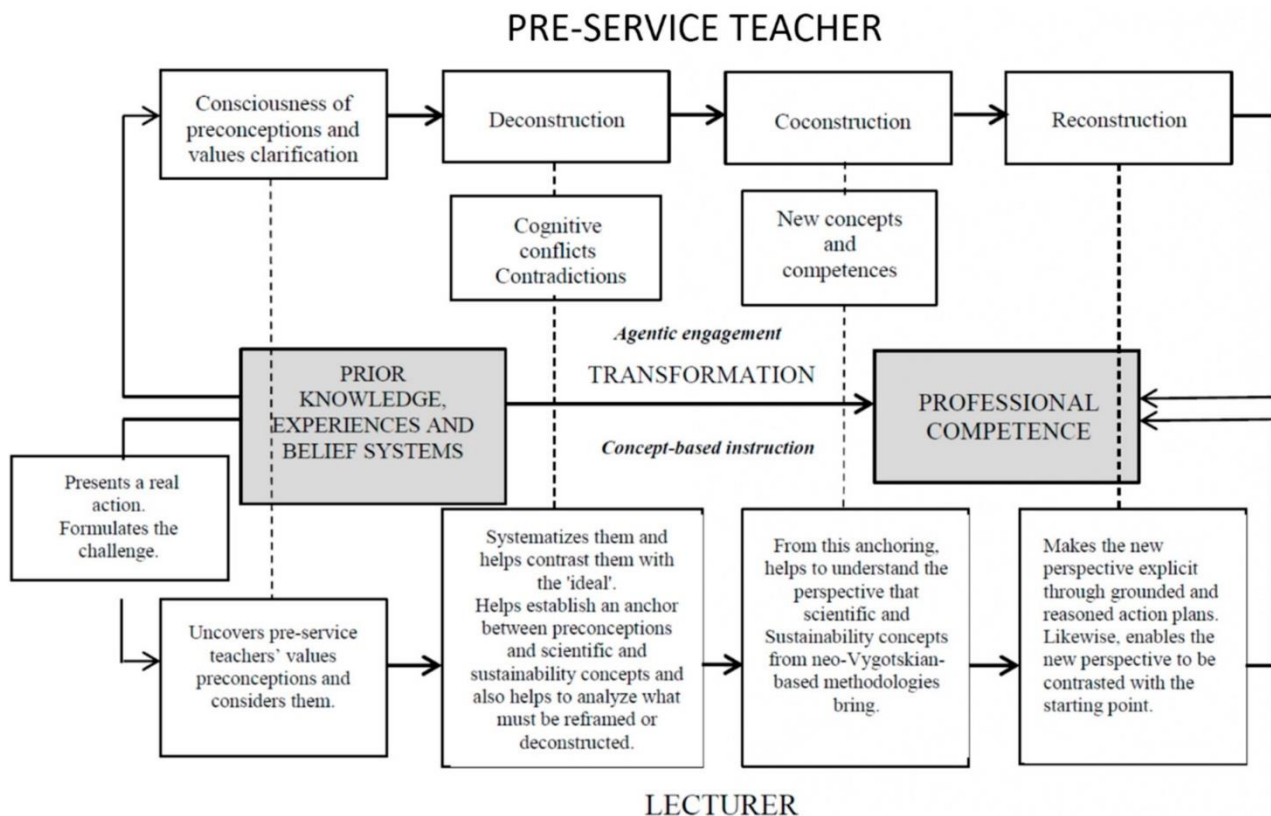
In the field of Mathematics Education, research in this regard is still scarce and reflects a lack of clarity as to how to rethink and reconsider how mathematics is taught and learned based on 21st century learning priorities (Alsina, 2022). This lack of research is further aggravated in the case of Statistics Education. Despite this, recent studies are beginning to shed light on how to integrate ESD into the teaching and learning of mathematics and statistics.

Alsina & Mulà (2019), in an effort to advance the incorporation of sustainability into teacher training, developed the Transformational Professional Competence Model through Reflective Learning and Sustainability (Figure 1).

This model describes strategies to promote the transformation of the knowledge of pre-service mathematics teachers within the framework of ESD and using the realistic-reflective training model. Based on this model, Vásquez (2020) promotes the incorporation of competencies linked to ESD through Statistics Education, since “data are not just numbers, but numbers in context” (Cobb & Moore, 1997). Therefore, statistics education is a powerful tool to bring sustainability into the school classroom in all its dimensions (Guterres, 2020).

From this perspective, Vásquez et al. (2020), analyze the conceptions of pre-service elementary teachers and pre-service kindergarten teachers regarding their competencies to incorporate ESD into the mathematics classroom. The results show little clarity regarding ESD and its scope, despite being acknowledged.

**Figure 1.** Transformational Professional Competence Model through Reflective Learning and Sustainability



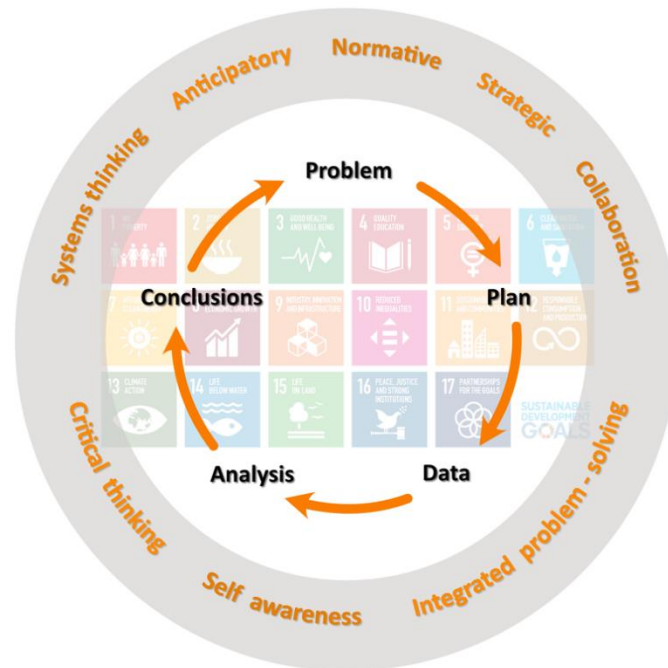
Source: (Alsina & Mulà, 2019, p. 13, CC by).

With the aim of making progress in this direction, Vázquez et al. (2021) analyze the presence of sustainability in the statistics and probability problems in a collection of Chilean textbooks on elementary mathematics. The results show a low focus on sustainability. Vázquez et al. (2022) also examine the mathematical curricular approaches to primary education in Chile, Colombia, Mexico and Costa Rica. The results show that the learning objectives linked to the content blocks involving statistics and probability, as well as numbers and operations, are the ones that most denote a relationship with the development of competencies that are essential for sustainability.

This provides a glimpse into the nature of Statistics Education as a fertile ground to educate in sustainability. To address this challenge, according to Vasquez & Alsina (2022), an important aspect is working with statistical projects in context of sustainability (Figure 2).

It should be noted that the success of this challenge requires a change of mentality, whose success lies in the beliefs, knowledge and competencies of teachers as key elements to move towards the integration of ESD into Statistics Education.

**Figure 2.** Connections between the cycle of statistical enquiry and education for sustainability (Vásquez & Alsina, 2022).



### 3. METHODOLOGY

Our analysis relied on a multiple case study (Stake, 2020) of a descriptive type of a qualitative and interpretive nature (Cohen et al., 2018).

#### 3.1. Context and participants

A non-probability sampling was employed to select the sample contains 11 Chilean primary education teachers who, when they participated in this research, were teaching mathematics in the fifth to eighth grades, that is, to students ranging in age from 10 to 13 years old. The characteristics of the teachers involved in this study are shown in Table 1.

It should be noted that only one of the teachers involved (P3) received training on sustainability while studying to become a teacher. The participants were recruited by means of open invitations that were sent to the directors of schools, who forwarded the invitations to the teachers, all of whom subsequently and voluntarily signed the informed consents.

**Table 1.** Characteristics of the participating teachers

Code	Gender	Experience (years of service)	Type of school where he/she teaches
P1	Woman	22	Public
P2	Woman	3	Semi-private
P3	Man	1	Private
P4	Woman	2	Private
P5	Man	9	Public
P6	Woman	14	Private
P7	Woman	10	Public
P8	Woman	13	Private
P9	Man	1	Semi-private
P10	Man	12	Semi-private
P11	Woman	8	Public

### 3.2. Data collection

Each participant underwent an in-depth semi-structured interview using the in-interview guide approach (Cohen et al., 2018). Thus, the application of semi-structured interviews made it possible to further analyze the subject in question by providing an instance of reflection to delve into the belief system involving the dimensions and sub- dimensions shown in Table 2.

**Table 2.** Characterization of the dimensions studied

Dimension	Sub- dimension
Teaching of statistics	<ul style="list-style-type: none"> <li>• Purpose</li> <li>• Statistical enquiry cycle</li> <li>• Role of context</li> </ul>
Sustainability and SDG	<ul style="list-style-type: none"> <li>• Knowledge, definitions and objectives</li> <li>• Competencies to be developed in students to promote sustainability</li> </ul>
Links between statistics education and sustainability	<ul style="list-style-type: none"> <li>• Statistics education and sustainability: strategies and practices</li> <li>• Challenges of teaching statistics with a focus on sustainability</li> </ul>

An application protocol was developed that contained suggestions for conducting the semi-structured interview, as well as the driving questions to ask over the course of said interview (Table 3).



**Table 3.** Driving questions used

Aspect	Question
Teaching of statistics	<ul style="list-style-type: none"> <li>• What do you see as the purpose of teaching statistics in school?</li> <li>• Are you familiar with the statistical enquiry cycle? What role do you assign to it when teaching statistics?</li> <li>• What importance do you attach to context, to the use of real data, when teaching statistics? How do you tackle this challenge?</li> </ul>
Sustainability and SDG	<ul style="list-style-type: none"> <li>• How would you define sustainability? Do you know anything about the SDG? Do you think they should be included in school? If so, how?</li> <li>• According to UNESCO, ESD is an educational approach that enables students to make decisions and act, in their personal lives and in their communities, in pos of the SDG. The goal is to challenge students' mental models and prepare them to be critical and innovative citizens who can solve complex problems and create alternatives to current unsustainable models.</li> <li>• Based on the above, what competencies do you think need to be developed in elementary students in order to promote the development of ESD?</li> </ul>
Links between statistics education and sustainability	<ul style="list-style-type: none"> <li>• When you teach statistics, how do you or would you relate it to sustainability?</li> <li>• What specific activities allow or would allow you to relate statistics education and sustainability in your classes?</li> <li>• Which of the SDG do you think may be interesting to cover in a statistics class? Why?</li> <li>• What obstacles do you think there may be to statistics education with a focus on sustainability?</li> </ul>

It should be noted that during the process of designing and conducting the interviews, care was taken to comply with the quality criteria proposed by Kvale (1994). The interview was also calibrated by the team of researchers involved and validated using the judgment of five experts (Table 4).

**Table 4.** Profiles of the experts involved in the validation process

Expert	Profile
1	Chilean. Primary school mathematics teacher. PhD Candidate in Education. Research area: teacher training.
2	Spanish. Secondary school mathematics teacher. PhD in Education. Research area: statistics education and sustainability.
3	Mexican. Secondary school mathematics teacher. PhD in Education. Research area: environmental education.
4	Spanish. Primary school mathematics teacher. PhD in Education. Research area: teacher training and sustainability.
5	Chilean. Primary school mathematics teacher. PhD in Education. Research area: teacher training and sustainability.

For the validation process, an invitation letter was emailed to the experts explaining the context of the research project that gave rise to the need to design and build the semi-structured interview, its description and purpose; the initial version of the instrument, its specifications table and guidelines to evaluate the adequacy of each driving question. Using a Likert scale of 1 to 4, the experts assessed three aspects in relation to each question: clarity, relevance, and consistency. In addition, they had a section for comments.

Once the information was collected, the scores assigned by the judges were analyzed. A descriptive analysis of the content's validity was conducted based on the values assigned to each driving question in terms of its clarity, relevance and consistency. The analysis was subsequently completed with an inferential study, using the Aiken index (Aiken, 1985) to quantify the degree of agreement or concordance between the scores assigned by the experts, which was 0.83 considered acceptable.

Thus, based on the evaluations and recommendations made by the experts, the instrument was reviewed, and the relevant adjustments were made. Subsequently, the final version of the instrument was tested (using a teacher not in the study sample). This was done in order to obtain empirical information on the implementation of the instrument with respect to its applicability, use and approximate duration.

The semi-structured interviews were administered using video calls. The resulting recordings were subsequently transcribed for processing.

### 3.3. Data analysis

The data obtained in the interviews were analyzed by developing in a deductive (and to a lesser extent inductive) way a hierarchical and ordered structure of the concepts or information contained in each text or answer. This was done, as per Miles et al. (2014), using a strategy of analyzing response patterns (common discursive structures) to identify the recurring themes that emerge from the answers and that facilitate their interpretation, as well as their relation to the categories considered in the design of the interview. Thus, the structure took on the form of an array that was logged in an MS Excel® 16.71 spreadsheet containing the contents (answers).

Accordingly, the research design executed, and the way data are analysed guarantee credibility, dependability and confirmability of the following results.

## 4. RESULTS

The results presented below are organized around the various dimensions involved.



## 4.1. Teaching of statistics

### 4.1.1. Purpose

With regard to the purpose of teaching statistics, two types of responses are observed. On the one hand, those that aim to explain what the teaching of statistics consists of agree on the interpretation of information as a central point, which is expressed with specific theoretical contents involved in the subject. An example of this is the answer by P1, who notes that “in fact, numbers deliver information (...) they involve the mode, the median, all those topics”. Along this same line, other teachers complement this definition, warning about the risks of not having the ability to interpret information, for example: “I believe these are life skills, like deducing information from a set of data to make sure the wool is not being pulled over our eyes” (P8).

Based on this type of approach, we observed that teachers constantly allude to the meaning that statistics has for their students, pointing out the importance of developing skills to interpret data as a part of understanding the world we live in and the information we work with on a daily basis.

Another group of answers highlights the relevance of teaching statistics and agrees on an element that is common to almost all the answers: the role that these subject plays in engaging with practical and realistic situations. In this sense, the purpose of teaching statistics is related to the possibility of giving students ‘tools’ to interpret the world and their environment. An example of this is the following answer:

Statistics is a tool that allows them to study social situations, their own life, their experience, what they see, what they read, what they hear (...) If managed properly, oriented towards the lives of students, towards their concerns, their interests, I think it can be a very powerful tool. (P3)

### 4.1.2. The statistical enquiry cycle

The answers analyzed make it possible to determine that the teachers in the study are not familiar with the SEC. For the most part, their answers indicate that they do not know the SEC, and if they claim to know it, they then add that “I know it, but I don’t remember it, I may have some notions” (P5). However, many of the answers manage to articulate some ideas where, with varying degrees of precision, they intuit some of the characteristics of the SEC. Within this generalized trend of ignorance, intuitions, or relatively imprecise memories, there was one exception, since one of the teachers claimed to know the SEC, and accurately described it:

Yes, I am familiar with the statistical enquiry cycle (...). What we do has a meaning. We look for data, we collect them, we use them for something, and then we sort them in a certain way so as to analyze them, which allows us to draw certain conclusions that could lead to new questions (P3).

This answer reveals the various moments of the SEC, namely: problematization based on the observation of a significant situation, production/search for data, ordering or planning of actions, analysis and conclusions.

### 4.1.3. *The role of context*

One of the most recurring topics in the interviews was to refer to the role of context as a strategy to teach statistics. In order to represent the heterogeneity of the answers analyzed, it is important to establish a distinction at three different levels of what the teachers provided as context. On the first level, the context was presented as the most immediate reality of the students, be it the direct environment where they live, the habits in their homes, and perhaps even more unique, the classroom itself with the interactions that take place there. In this area, teachers invite their students to think statistically about their surroundings. For this type of approach, the creation of data from information collected by the students themselves is key, which explains the following statement: “they build and look for data. We ask the question, they investigate, and they can generate it by searching for the data” (P10). The second level involves social reality at the national or even global level, with a focus on current events. However, especially with students in upper primary school, the view of the role of context tends to shift from the most immediate reality to what could be understood as a social, national or global context. In this regard, many teachers decide to continue working with real data, but instead of producing them themselves in the classroom, they use statistical information provided, for example, by Chile’s National Institute of Statistics (INE), in the national press or online. Based on the interviews analyzed, in general this type of activity seeks to show students how a knowledge of statistics connects with a critical and informed view of reality; for example, a respondent uses the criterion of what the students sense as fair and unfair as a way to approach study problems: “the subject of pensions, which is also unfair, the quality of life you can expect” (P1). On the third level, and as an intermediate between the previous ones, the problem of the students’ own interests becomes evident. In most cases, teachers use these interests to venture away from the more familiar without losing touch with issues that make sense:

Their hobbies, music or musical styles, how long they spend in school, etc. I think this is something that motivates them completely and that hooks them or connects with them so they can study it through statistics. (P4)

In this type of approach, music and sports tend to be well represented in the teachers’ answers. However, the focus on interests also provides a useful way to discuss more wide-ranging problems; for example, in interdisciplinary efforts, where, without departing from the premise that it is the students themselves who choose the problems, they are invited to think about problems that go beyond their hobbies, for example: “the children make a survey about which native people they would like to learn about” (P6).

## 4.2. Sustainability and SDGs

### 4.2.1. *Knowledge, definitions and objectives*

Regarding sustainability, most teachers say that they do not know its definition, directly stating “I wouldn’t know how to define it” (P8), or in some cases they nuance it: “I have a sense of what it is” (P7). Despite this initial approach, most

manage to articulate certain ideas and associate elements that give shape to what we could describe as a general domain that, in their own words, intuit what sustainability is. In this area, their answers mainly contain elements involving reflections on nature and the environment, the use of resources, clean water, the environment, and the like. For example, some teachers say: “optimize the resources available in nature, use them well. To me, that is what sustainability is, and everything that entails” (P6). In one particular case, one of the teachers stated having had the opportunity to conduct research on sustainability and the SDGs, and was able to provide a more precise and articulate response with respect to these two issues compared to the previous ones, not only giving a definition, but also pointing out some of the elements that comprise it, its purposes, and ending with a reflection regarding the problem:

Sustainability is defined as a system through which we try to make sure that after our time on Earth, and that of future generations, that it remains habitable, livable while living with dignity (...) the SDGs helped me open my mind much more to understand sustainability. (P7)

In relation to the SDGs, we see two groups of responses: one group that rightly claims not to know them or not to remember them, such as: “I’ve heard of them, but I don’t remember the sustainability goals” (P9); and a second group with answers from teachers who more or less accurately not only mention some of the relevant themes of the SDGs, but also give some examples of how they have presented them in their classes. An example of this is the following answer:

I know the SDGs; in fact, I am now working on SDG2, which is zero hunger. We combine natural sciences with mathematics. I am teaching fractions and decimals and we merge that with the science teacher, who is covering healthy eating, in order to address food waste. (P6)

Here, the knowledge of the SDGs is precise, as this teacher is able to describe the work done in specific classes with one of the goals, and how this is approached across subjects with other teachers in the school.

#### *4.2.2. Competencies to be developed in students to promote sustainability*

In this regard, the responses show some uniformity around four major themes: a) empathy and respect; b) critical thinking and autonomy; c) collaborative work and dialogue-based relationships; and c) awareness of the challenges of today’s world.

- a) Empathy and respect were the most mentioned topic in the interviews. Empathy in particular played a central role in the concerns expressed by the respondents, who noted with concern the need to continue working with having their students put themselves in one another’s place:

I think it’s empathy and it’s severely lacking, because especially after the pandemic, while individualism was already noticeable before, now in society it is more noticeable and in children, it is especially so. (P7)

This helps us understand the following statement: “empathy for what others do not have, an appreciation of the common good, of common space, solidarity” (P6). As we can see, the key difference between the two answers is that the first

refers to empathy in more abstract terms, in opposition to individualism, and it establishes a causality (COVID-19 pandemic) between two elements devoid of content. By contrast, the second answer provides some specific elements such as awareness of the material reality of others, the common good, common spaces, solidarity.

b) Critical thinking and autonomy are a recurring theme in the responses. A critical approach to problems is identified in multiple answers as a skill that must be developed. This vision recalls certain philosophical positions that refuse to understand criticism as pure negativity, as a simple intellectual rejection of the positivity of what exists (Foucault, 2019), and is rather an attitude towards life, where informed positions are taken urgently and autonomously. This perspective of criticism is clearly reflected in the following statement:

How they [the students] can be empowered by information to criticize those around them and also to be part of the changes that are proposed. I think it's like the central theme, but it also has a lot to do with the subject of information. How to recognize how false information can be, or these graphs they show us sometimes, but that aren't so real, the influence that has. I think that is an important part and then there are current events, where they choose the topic and work with it, also with the data we already have. (P8)

This view of criticism is closely related to autonomy. That is, it is understood as a skill that each student is able to think for himself based on a well-founded opinion:

Critical thinking is also something that needs to be developed, because they don't really think things through. (...) or they copy the same idea as the rest, or what someone else said (...) the boys are very reliant, they need to be more independent in their work. (P7)

c) Collaborative work and relationships based on dialogue are widely identified in the answers as skills to be developed. The allusions to collaborative work have dual facets: on the one hand, as a practical and useful competence to develop in everyday life, and, on the other, as a way to approach the training of students. From this perspective, some respondents note that teamwork is a tool for the development of skills, and at the same time, it fosters the development of ethical attitudes, going from the simple distribution of roles towards awareness for others. "I believe that collaborative work [is an important skill], suddenly they always prefer to work alone rather than collaboratively" (P2). Analogously, another respondent stated that honesty is essential when it comes to generating those collaborative spaces in the classroom, being the basis of what we could qualify as the creation of dialogic spaces: "not to falsify information (...) as simple as that. I don't know how to express it, but... peer-to-peer dialogue, argumentation, I always strive for that in my classes in general" (P9). In this sense, working from a statistical point of view is proposed as a way to develop intellectual honesty, essential to developing tools for reasoning, but also for dialoguing with peers.

d) Awareness of the challenges of today's world was mentioned by some teachers who view it as a fundamental aspect to be developed in the classroom.

They posit the need to develop in students an awareness of the environment in general, and an ecological awareness in particular, for example, as expressed in the following quote:

Using real data from current situations helps students understand the climatic situations that we are seeing at this time, and which are more pressing, or which are of concern. (P3)

### 4.3. Links between statistics education and sustainability

#### 4.3.1. *Statistics and sustainability: strategies and practices*

Regarding this topic, the teachers' responses mainly point to two elements, one involving the problems or phenomena that make it possible to cover both subjects (poverty, health, well-being, constitution, etc.), and the other related to strategies that they would employ in their classrooms. It is important to note that in most cases, the answers reported here are presented as ideas that the teachers propose but have not implemented. Along these lines, and considering the first set of answers, insofar as they indicate a potential specific problem (rather than a specific strategy or practice) to address in class, one respondent says:

[Referring to the SDGs] I think that health and well-being is also an interesting topic, since it can relate to the subject of life, of healthy life in school. For example, in my school one of the tenets is that, to promote healthy life in the students. Then you could also take this topic and really see what activities the school promotes, what the habits of students are, survey them on their main sports activities, and somehow connect all of this throughout all of the subjects taught. (P4)

This story goes beyond presenting only the problem-content, connecting different elements that can be discussed in classes in a single action: health and well-being (SDG), the educational project of the school, the teaching of statistics through surveys, and interdisciplinary work. Thus, based on this answer, it would be possible to deal simultaneously with institutional objectives (school tenet), SDGs (health and well-being) and teaching strategies (surveys and interdisciplinary work), resulting in a simultaneous approach to the objectives of the activities.

Some answers exhibit a more detailed level of possible activities to undertake. In the case presented below, one of the teachers explains how she works on the link between statistics and sustainability with her students:

First, I plan to do a project, give them some topics to investigate, and based on the research question, define how they are going to find the data, and give them a different goal each week. First week, search for information, define the topic, research question. The second week, think about how I am going to collect data, from where, from what source, if a survey is needed and based on that survey, make graphs (...) the topics to choose from could be the ones that appear in the Constitution proposal. (P8)

As we have seen, there are varying levels of complexity in their answers regarding how they would incorporate statistics and sustainability into their classes. This testimony coincides with the one immediately preceding, insofar as it

expresses an interest in working on both statistical and sustainability learning objectives simultaneously.

An exceptional case is that of a respondent who in her answer mentions exclusively statistical contents as central: “statistical graphing proposes the issue and conclusions can be drawn. I think that is easier to do in statistics, but it is more direct because I can use whatever the information is, the information is the excuse” (P7). This answer does not allude specifically to sustainability or the SDGs, but rather points to the versatility of statistical graphs to deal with any type of information. In this sense, data would be ‘the excuse’, the medium, and not the end in itself; that is, data (for example, those related to the SDGs) would be a means for learning how to interpret and construct statistical graphs.

#### *4.3.2. Challenges of teaching statistics with a focus on sustainability*

Regarding this topic, we see that the majority of the respondents’ answers (with some exceptions) refer to the teaching of statistics in combination with sustainability, as a simultaneous process. It seems important to emphasize this point, because it shows that the teachers seem to think that the learning process of students is intertwined with different purposes or objectives, recognizing their complexity. Moreover, on several occasions the idea of working across disciplines is mentioned, proposing activities such as projects to address multiple objectives in a single educational experience. That said, teachers report various problems involving the task of teaching statistics in combination with sustainability, and they highlight certain elements. The first element identified as a challenge by teachers is the lack of mastery of the contents that have to present in classes, such as, for example, statistical graphs:

I think the issue is that I’m not familiar with the number of graphs needed. Box diagrams, for example, are taught in eighth grade, and I know I have to study it because I don’t know them; that’s the truth. But beyond that, I know that there are other graphs that suddenly show up in the program and I don’t know them either. The usual graphs I know, but not the others. So that can make it difficult for me. (P7)

A second element the teachers view as a challenge is the knowledge of current events or issues that could be of interest to students, as evidenced by the following testimony:

There are some news subjects that I can work with, but I might need to expand my knowledge a little, because this limits the activities I can do, because if I don’t have more information, that will limit me. (P7)

A third type of element is one that alludes to the difficulty of developing sustainability skills in students, which they view as complex to develop. An example of this is the following answer:

What I find hardest is the challenge of developing certain skills, such as systems thinking, having the students being able to look beyond what the number is, what the reason is (...) the ability to see the big picture. (P3)



In this sense, the teachers' answers reflect a certain lack of confidence in their own abilities and knowledge to then make available during the teaching process, emphasizing different elements: the contents to be taught, a knowledge of current events, and mastery of complex learning processes in children and young people. What these elements have in common is that they are located in the individual, meaning they are perceived as personal elements that must be improved, a responsibility that lies with teachers, not external variables. Consequently, these elements must be considered when designing training programs for teachers.

## 5. DISCUSSION AND CONCLUSIONS

We present the main findings of this study organized around the three dimensions considered in this study.

*a) Teaching of statistics.* In general terms, teachers place great value on the teaching of statistics, considering it as a life skill, since it is used to interpret, evaluate and create information with elements that are all around us. This indicates that, in some way, teachers view the teaching of statistics as relevant knowledge, oriented to understanding the different phenomena of reality observable in the environment and considered a key tool for understanding both themselves as well as the environment in which the students live. In fact, the interpretation of the world through statistics is valuable on different levels, ranging from the individual (tastes, interests), group (family, school, neighborhood), to the national or global (poverty, pandemic, economy, global warming). They also acknowledge that the connection between statistics and phenomena from real life is intimately linked to the motivation of students to learn the subject. In this sense, statistics, unlike other content (such as algebra), is not understood in isolation, nor exclusively from their theoretical or abstract conceptions; rather, it is presented in connection with real problems that make the world and its phenomena understandable to students.

This conception regarding statistics corresponds to the ways it is presented when taught, which can be classified into two different levels: firstly, a pedagogical or propedeutic one, and, secondly, one referring to the very sense of statistics as a mathematical and extra-mathematical tool (Vásquez & Alsina, 2021). With regard to the pedagogical, it is clear that using real data, especially those produced by the students themselves, is a way to involve and generate more meaningful learning. On the second level, teachers argue that statistics is an analytical tool that exceeds internally mathematical limits, and provides a way of thinking that is critical, orderly, logical and based on the reality in which we live. In this regard, although teachers place different emphasis on topics such as gender, the environment or economic issues, we tend to see a convergence on the importance of teaching statistics using cases based on real data.

*b) Sustainability and SDGs.* In general terms, there is little precision around the meaning the teachers assign to these notions, which matches the results reported by Vásquez et al. (2020) with pre-service kindergarten and primary school teachers. However, and even though most of them declare not being familiar with this topic in theoretical or conceptual terms, they manage to articulate certain ideas and

notions that define an understanding of sustainability that could be described as intuitive. Elements related mainly to reflection on the environment stand out, as do, to a lesser extent, gender issues and social problems such as inclusion, poverty and health. This could be related to misguided ideas and notions of sustainability, a lack of clarity of its impact and areas of action, which go beyond the environmental to also incorporate social and economic dimensions.

This finding extends to the analysis of their understanding of the SDGs. That is, they have a general or intuitive grasp that allows them to mention or work with any of these objectives without giving them much precision (with some exceptions where teachers have a certain mastery in this area).

Finally, a certain uniformity is observed regarding the sustainability skills to be developed in students that are deemed relevant and feasible to be practiced in class. Of note is the focus on empathy and respect; critical thinking and autonomy; collaborative work and dialogue, which are useful skills to develop in any social context; and finally, awareness of the environment in general and ecological awareness in particular, which point to the relationship that human beings establish with the environment in which they live.

*c) Links between statistics education and sustainability.* Although there are many practices that teachers use to link the teaching of statistics to sustainability, it is possible to conclude that they welcome the educational possibilities that relating the two topics offers. This trend may be due to the characteristics of the sample, since many of them have general training with a specialization in mathematics, which may in some ways provides them with a general overview of the different disciplines, facilitating interdisciplinary work, as well as a greater fluidity to establish connections between the teaching of statistics and sustainability.

In this sense, one of the most interesting elements described in their answers is that the relationship between sustainability and statistics education is presented in an articulated way, being more than just examples (Vásquez & Alsina, 2021). We also noted that many of the answers involve the hypothetical rather than the concrete; that is, they refer to what could be done and only to a lesser extent to what they actually did.

Although most teachers recognize the importance of working with real data, in general, the topics considered for presenting statistical content still involve interests, hobbies or preferences, and only a minority of the answers acknowledge incorporating sustainability issues into everyday classroom activities when teaching statistics.

As for the challenges and obstacles that teachers recognize when establishing links between statistics and sustainability, there are many. One of the most recurring themes is their own mastery of content, of sustainability competencies and how to develop them in students.

Thus, the results underscore the need to use public policies to reconsider the initial and continuous training of teachers who teach mathematics and statistics in terms of sustainability, by allocating space and time in the training curricula to

critically reflect on teaching practices and on how to reorient them towards sustainability. As the processes employed in teacher training are enhanced, it will be possible to promote and reinforce the inclusion of sustainability in the school classroom. Therefore, it is imperative that teachers have tools to reflect on the role and nature of statistics education in order to establish connections between teaching this subject and various problems sourced from real contexts. If this is achieved, we will be contributing through statistics education to advancing the transformation of the way we relate to our environment and the world in order to build a better future together.

To do this, it is essential to consider the key role of teacher training institutions, and to call on them to build a common foundation at the curricular level around sustainability that prompts teachers to rethink the teaching, methodologies and connections between disciplines and contents in order to advance the integration of sustainability into the school classroom.

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Pontificia Universidad Católica de Chile (Chile)  
[cavasque@uc.cl](mailto:cavasque@uc.cl) | <https://orcid.org/0000-0002-5056-5208>

**María José Seckel**

Universidad Católica de la Santísima Concepción (Chile)  
[mseckel@ucsc.cl](mailto:mseckel@ucsc.cl) | <https://orcid.org/0000-0001-7960-746X>

**Francisco Rojas**

Universidad Autónoma de Barcelona (España)  
[franciscojavier.rojas@uab.cat](mailto:franciscojavier.rojas@uab.cat) | <https://orcid.org/0000-0002-0328-8156>

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## Conectando la educación estadística y la sostenibilidad: creencias del profesorado de Educación Primaria

Claudia Vásquez @ <sup>1</sup>, María José Seckel @ <sup>2</sup>, Francisco Rojas @ <sup>3</sup>

<sup>1</sup> Pontificia Universidad Católica de Chile (Chile)

<sup>2</sup> Universidad Católica de la Santísima Concepción (Chile)

<sup>3</sup> Universidad Autónoma de Barcelona (Spain)

Actualmente, el profesorado está desafiado a desarrollar la Educación para el Desarrollo Sostenible en el aula escolar. Para ello, un aspecto clave es propiciar un enfoque interdisciplinar de las diferentes materias que propicie la participación de los estudiantes a través de un aprendizaje activo y significativo, centrado en el desarrollo de competencias de sostenibilidad.

Ante este desafío, la enseñanza de la estadística tiene gran potencial producto de su naturaleza científica y matemática. Sin embargo, esta no es una tarea fácil y requiere un rol activo del profesorado. Por tanto, es necesario no sólo incorporar la sostenibilidad en su desarrollo profesional, sino también conectarla con materias específicas, como la educación estadística.

En este proceso, las creencias del profesorado pueden ser un obstáculo o un facilitador, por lo que nos proponemos investigar cómo el profesorado en activo vislumbra la conexión de la educación estadística y la sostenibilidad.

Con este propósito analizamos el sistema de creencias de once profesores chilenos de Educación Primaria en torno a la educación estadística y sus vínculos con la sostenibilidad. Cada participante fue sometido a una entrevista semiestructurada, centrada en tres dimensiones: enseñanza de la estadística, sostenibilidad y objetivos de desarrollo sostenible, y vínculos entre ambas. Los datos obtenidos en las entrevistas se analizaron elaborando, de forma deductiva, una estructura jerárquica y ordenada de los conceptos o informaciones contenidos en cada texto o respuesta.

En cuanto a los resultados, estos se organizan en torno a las tres dimensiones consideradas en el estudio. Respecto a la primera, la enseñanza de la estadística, identificamos tres cuestiones principales: el propósito, el ciclo de investigación estadística y el papel del contexto. Lo anterior, nos indica que el profesorado entiende la enseñanza de la estadística como un conocimiento relevante, orientado a la comprensión de distintos fenómenos de la realidad observables en el entorno, siendo considerada como una “herramienta” clave para la comprensión tanto de sí mismos, como del contexto en el que se desenvuelven los estudiantes. En cuanto a la sostenibilidad, identificamos dos componentes principales: definición y competencias. A este respecto, se evidencia que, a pesar de que la mayoría manifiesta no estar familiarizados en términos teóricos con esta temática, logran articular ciertas ideas y nociones que dan cuenta de un dominio que podría describirse como intuitivo respecto a la sostenibilidad y a las competencias por desarrollar en los estudiantes. Por último, la conexión entre la educación estadística y la sostenibilidad se caracteriza por una valoración positiva respecto a los puentes que se pueden tender entre la educación estadística y la sostenibilidad.

En resumen, a partir de los resultados, se evidencia la necesidad de replantear desde las políticas públicas la formación inicial y continua del profesorado que enseña matemática y estadística en términos de sostenibilidad, otorgando espacios y tiempo en los currículos formativos para reflexionar críticamente acerca de las prácticas de enseñanza y sobre cómo reorientarlas para una enseñanza en conexión con la sostenibilidad y las competencias de sostenibilidad.