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Teaching, Learning and Assessing Statistics in a program in Educational Sciences: challenges and reflections[1]

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ABSTRACT

During the first semester of the year 2022, a partial evaluation focused on the strategy of solving contextualized problems was designed and implemented in the subject Statistics in Education of the Teacher and Bachelor of Education Sciences of the National University of Salta in order to promote the development of statistical culture skills in its manifestations: literacy, reasoning and statistical thinking. To this end, a research cycle focused on the topic: "University Academic Pathways: Between Inclusion and the Effects of the Pandemic at the National University of Salta". The approach of descriptive statistics contents was planned in order to develop the different stages of statistical research with partial submissions for formative feedback and the presentation of a brief report as a partial evaluation.

KEYWORDS: Teaching of statistics; Statistical reasoning; Formative assessment; Educational sciences.

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Ensinar, Aprender e Avaliar Estatística na carreira de Ciências da Educação: desafios e reflexões

RESUMO

Durante o primeiro semestre de 2022, na disciplina de Estatística em Educação dos cursos de Licenciatura e Bacharelado em Ciências da Educação da Universidade Nacional de Salta, foi projetada e implementada uma avaliação parcial centrada na estratégia de resolução de problemas contextualizados com o objetivo de promover o desenvolvimento de habilidades próprias da cultura estatística em suas manifestações: alfabetização, raciocínio e pensamento estatístico. Para isso, foi utilizado um ciclo investigativo focado no tema "Trajetórias acadêmicas universitárias: entre a inclusão e os efeitos da pandemia na Universidade Nacional de Salta". Planejou-se a abordagem dos conteúdos de estatística descritiva de acordo com o desenvolvimento das diferentes etapas da pesquisa estatística, com entregas parciais para feedback formativo e a apresentação de um breve relatório que teve caráter de avaliação parcial.

PALAVRAS-CHAVE: Ensino de Estatística; Raciocínio estatístico; Avaliação formativa; Ciências da Educação.

Enseñar, Aprender y Evaluar Estadística en una carrera en Ciencias de la Educación: desafíos y reflexiones

RESUMEN

Durante el primer semestre del año 2022, en la asignatura Estadística en Educación de las carreras del Profesorado y la Licenciatura en Ciencias de la Educación de la Universidad Nacional de Salta se diseñó e implementó una evaluación parcial centrada en la estrategia de resolución de problemas contextualizados con el fin de promover el desarrollo de capacidades propias de la cultura estadística en sus manifestaciones: alfabetización, razonamiento y pensamiento estadístico. Para ello, se trabajó con un ciclo investigativo centrado en la temática: “Trayectorias académicas universitarias: entre la inclusión y los efectos de la pandemia en la Universidad Nacional de Salta”. Se planificó el abordaje de los contenidos de la estadística descriptiva en orden al desarrollo de las distintas etapas de la

investigación estadística con entregas parciales para la retroalimentación formativa y la presentación de un breve informe que revistió carácter de evaluación parcial.

PALABRAS CLAVE: Enseñanza de estadística; Razonamiento estadístico; Evaluación formativa; Ciencias de la educación.

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Introduction: Contextualization of the experience

In Argentina, statistics contents are included in all compulsory levels of the Educational System. Both in the Curricular Designs and in the Core Learning Priority - CLP (Ministry of Education, Science and Technology, 2006) and in the Indicators of Progress for Priority Learning - IPL approved by Resolution of the Federal Council of Education No. 342/18, Statistics and Probability are identified as one of the four key areas to be developed in the different years, with an progressively increasing level of complexity in terms of concepts and approaches as students progress through their schooling.

Regarding this, researches such as Garibotti et. al. (2020) and Ferrante, Vivera and Astiz (2019) mention that, despite the recognized social relevance and its inclusion in curricular documents, statistics contents historically takes a secondary role in education. In their works, some of the reasons mentioned refer to the order of the topics established in the lesson plans and textbooks, the lack of time for their treatment, and, in some cases, the training of teaching professionals that is focused on a rather abstract character and limited in terms of the didactics of Statistics. All this poses a topic of interest in research, recognized both by the International Commission on Mathematical Instruction (ICMI) and the International Association for Statistical Education (IASE). They are currently organizing the Joint ICMI/IASE Study: Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education (ICMI; IAISE, 2007).

In the university context, it is assumed that students have progressively developed a series of skills and abilities through their earlier levels of the education system. However, based on what was mentioned earlier, it is necessary to review this assumption in relation to the competencies that allow making sense of and working with statistical contents because in general, "students arrive at the University with little or no training in statistical reasoning and thinking" (Tauber, Santellán & Cravero 2019, p.1).

This experience took place in the year 2022 within the framework of the subject Statistics in Education, which is part of the second year syllabus of the Teacher Training and Bachelor's Degree in Educational Sciences at the National University of Salta, Argentina. This is the only course that specifically offers elements for a quantitative approach in the Teacher Training Program. In the case of the Bachelor's Degree program, it lays the foundations for the work carried out in the Research Methodology in Education in the 5th year, which has a quantitative-qualitative approach, with an emphasis on quantitative methods.

In this regard, the subject initially aims to contribute to the development of statistical literacy by working on the two capacities proposed by Gal (2002) in the definition of the process. These capacities involve interpreting and critically evaluating data and statistical information presented in different contexts, as well as to communicating this information adequately while understanding its significance and taking positions on its implications. It is understood that the development of these fundamental skills lays the foundation for students to be able to organize, summarize, present, read and interpret information acquired through the measurement of real-world phenomena.

Following these guiding principles, since 2015, a dimension has been included in the initial students survey to gather information about their experiences in dealing with statistical content in previous educational levels and their perceptions regarding their understanding. Regularly, more than

70% stated that they had not worked on these contents at school. Among those who stated that they did study these topics, more than 50% considered that they had a limited mastery of what they had learned based on the grades they had obtained.

Considering these assessments, the pedagogical intention that guided the planning of didactic interventions in the subject was to promote the development of statistical thinking in non-mathematical university students by implementing techniques, procedures and reflections to help students understand, process, analyze and use data, mainly related to the educational field, in an proper manner.

In addition, the decision was made to accompany the students' learning process from the perspective of formative assessment in the field of statistics. This approach had the aim of guiding students so that they could master certain skills and self-regulate their learning. The focus was on the learning process rather than just the final outcome, which allowed students to improve their performance and understanding of the topics at hand. As a result, the role assumed was that of accompanying, encouraging and orienting the student while the student took on the challenge of learning something new from a more active, participatory and engaged role in the construction of their own learning. In other words, an emphasis was placed on developing a dialogical and collaborative relationship between the teacher and the student as well as between the student and their classmates.

From this perspective and considering that assessment is inherent to the teaching and learning processes, the decision was made to share the experience of the partial assessment developed in this communication.

The educational experience from a real context

In higher education, the year 2022 was a transition period following the abrupt changes in educational practices brought about by emergency

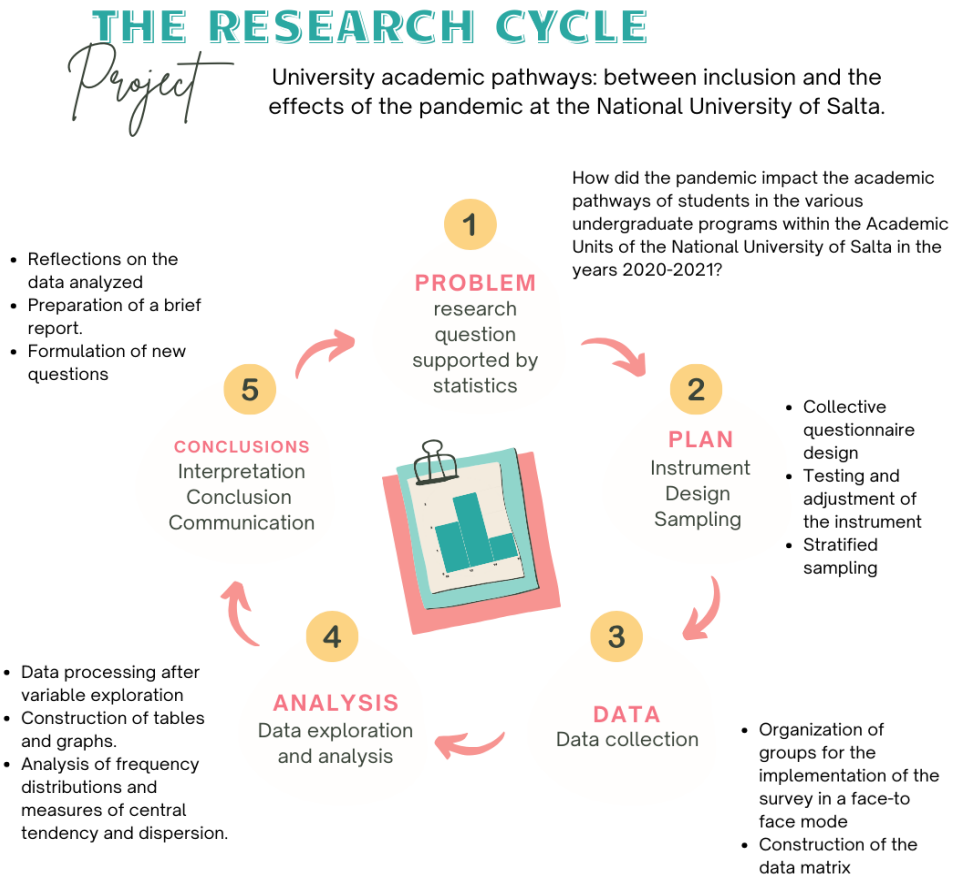
virtualization in 2020. It was a time when institutions began implementing combined or hybrid models of education, incorporating both virtual and in-person elements within the context of the "new normal" in 2021. Additionally, it was a year characterized by reflections, debates, agreements and regulatory and organizational decisions concerning pedagogical interventions in full in-person instruction. These decisions were informed by the lessons learned during the public health crisis in the previous year. The pandemic challenged the continuity of practices as we knew them, unexpectedly and abruptly altering the usual modes of operation of educational institutions in terms of management, organization and pedagogical work (Olarte; Velarde, 2022, p.119).

During the first classes of the academic year 2022, students frequently mentioned the effects of the temporary closure of educational institutions, the characteristics and limitations of the contingency work proposals and the inequality in terms of technology availability and proficiency.

During the meetings, there was a number of assumptions regarding the effects of the working formats during the non-face-to-face instruction and the alternation between face-to-face and virtual learning in academic pathways. Clearly, the students felt engaged with a scenario in which they played a significant role. This shared interest within the group presented an opportunity to encourage critical examination of the situation, the possibility of framing the problem in terms of data, and consequently, the need to seek out data.

After successive exchanges in the classroom, it was possible to define together with the students the statistical problem to be addressed through the implementation of a research cycle (Wild; Pfankuch, 1999). The question that guided the search for answers in the project work was: How did the pandemic impact the academic pathways of students in the various undergraduate programs within the Academic Units of the National University of Salta in the years 2020-2021?

FIGURE 1 - Project Evaluation Outline. Statistics in Education, 1st semester, 2022.



Source: made by the author.

The development of the different stages involved in the process was planned in six weeks considering periods of work with the entire class group and others in groups of four members, since the final presentation of the report was proposed to be done as a group.

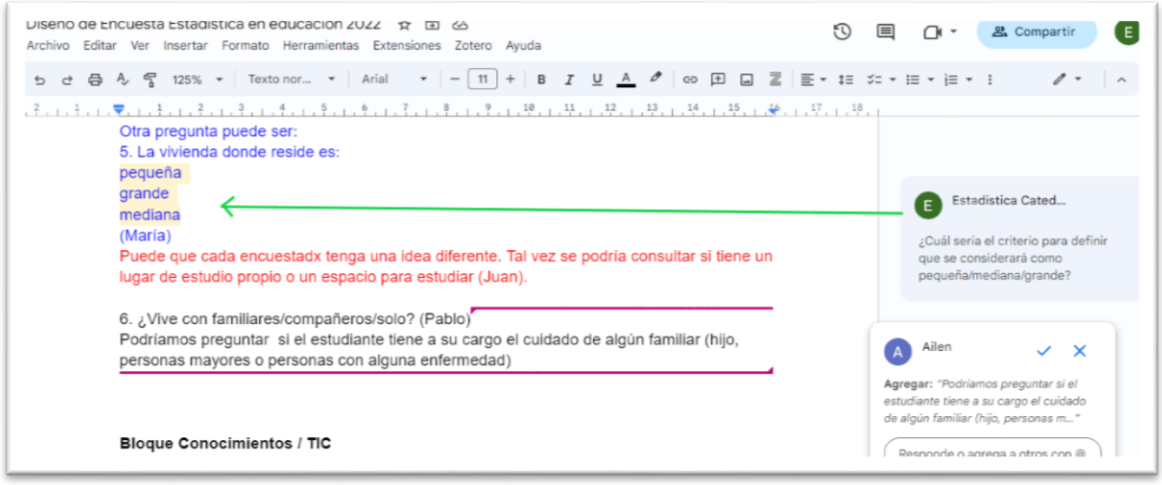
Throughout the implementation of the midterm assessment, various instances of formative dialogic feedback were considered (Anijovich & Cappelletti, 2020; Black & Wiliam, 1998; Sadler, 2010). This feedback was understood as an open and constructive dialogue between the teacher and the student. In each face-to-face and/or virtual meeting with the students, questions were posed, additional data was requested, doubts were clarified, students were encouraged to seek their own answers and to analyze the

feedback provided. This was done in order to help them understand where the mistakes occured and how they could use this information to improve the processing, analysis and subsequent communication of the results of their midterm work.

The first week of work was dedicated to defining what to measure and how to do it. To achieve this, the research question was operationalized into variables and the data collection instrument (survey) was designed. The type of sampling (stratified) was determined and the sample size to be considered in the study was calculated. These activities were conducted during in person and/or virtual meetings.

In this stage, a strategy for descriptive and focused feedback called Write, Comment and Advance! (Carless et al., 2011) was implemented. Students worked on a shared document where each group had to contribute questions for capturing the variables of interest along with justifying their inclusion. Continuously, the work was reviewed and guidance was provided, with appropriate questions visually highlighted, areas for improvement identified, and suggestions given on how to improve the work. Thus, through technology-assisted dialogue, reflective interaction was strengthened and students worked to improve their contributions.

FIGURE 2 - Example of the feedback strategy and student comments.



Source: made by the author.

The description of the designed survey serve as informed consent. It outlined the research objectives, the institutional framework of the work and how the information would be handled in accordance with the principles of Statistical Secrecy (Law No. 17622) and personal data protection (Law 25326).

FIGURE 3- Academic Pathways Survey. Statistics in education, 1st semester, 2022.

Source: made by the author.

During the second week, a pilot survey was carried out. In this stage, the *favorite error* strategy was used during the instrument testing phase. By collectively reviewing the questions defined in the questionnaire, the students were able to recognize the importance of phrasing the questions in an appropiate and understandable language taking into account the specific characteristics of the individuals being surveyed. This made it possible to highlight a factor for minimizing non-responses and avoiding the accumulation of lost cases. This type of intervention promoted the students' metacognition of the survey design and their commitment to the activity itself.

Subsequently, the questionnaire was refined and data collection began with its administration by students over a period of two weeks. Then, the surveys were entered as a Google Form to build a matrix.

The analysis of the collected data and its quality as well as the cleaning, reduction and consolidation of the matrix was carried out during the fourth week. At the same time, there was an effort to reflect on the challenges encountered during the survey administration and the relevance of the observed data in answering the research question that originated the study.

At this stage, the modifications proposed by the students to the instrument and its future application methods were particularly interesting.

> "in the application of the survey I realized that the responses required more time than we had initially thought and that made the participants' attention to wander. I think it could be better focused and reduce the number of questions." (Lucia)
>
> "some questions in the Academic Pathways section were confusing for the students, especially those referring to the number of subjects taken in different years. Maybe we could only refer to a single year..." (Noelia)
>
> "The questions about origin, residence, and residence during the pandemic generated confusion. I had to explain several times the difference between what was being asked in these three cases and the values we proposed for each. It's necessary to review that." (Pablo)

Considering the time of the year when this partial evaluation project was carried out and the topics covered in the program, students were able to work on the transnumeration process using the techniques mentioned by Chick (2004), namely: a) sorting, b) counting, c) frequency calculation, d) calculation of proportion and percentage, e) tabulation, f) graphical representation, g) calculation of measures of central tendency and, h) calculation of measures of dispersion.

In order to assess and regulate learning, a set of evidences and data on the research cycle was defined and translated into the following assessment rubric.

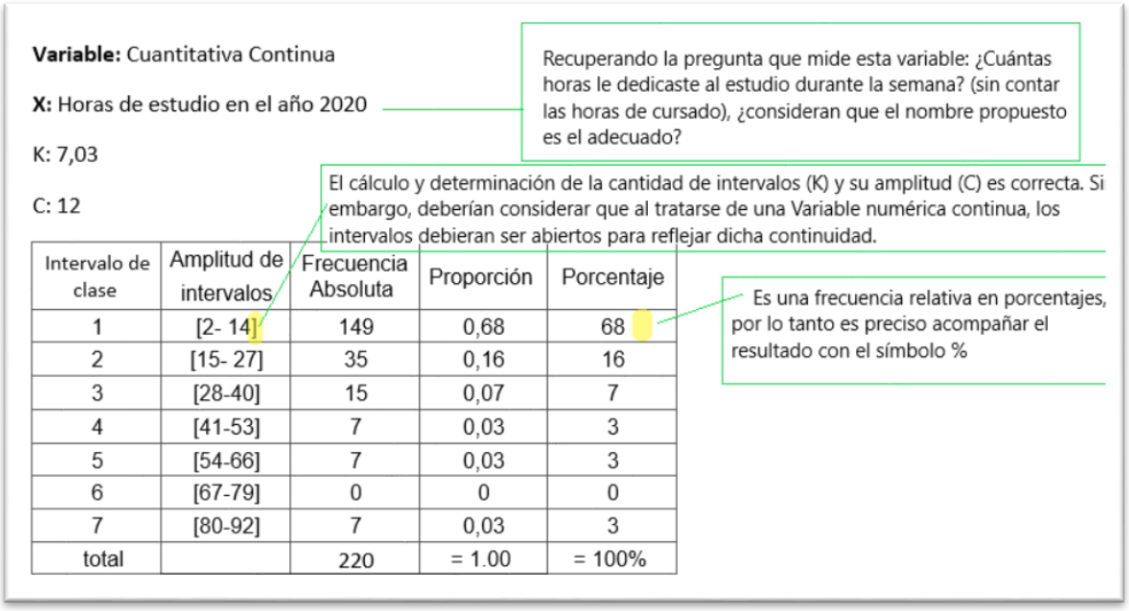
TABLE 1 - Assessment rubric. Statistics in education, 1st semester, 2022.

	EXCELLENT (4)	VERY GOOD (3)	GOOD (2)	NOT MET (1)
Representation of information in statistical tables and graphs	Correctly collects and organizes statistical information. Correctly represents any type of survey information in statistical tables or graphs. Explains how to represent information in statistical tables or graphs.	Correctly collects and organizes statistical information. Correctly represents statistical information in frequency tables. Correctly represents statistical information in graphs.	Collects statistical information. Has difficulty representing statistical information in frequency tables. Has difficulty representing statistical information in graphs.	Has difficulty collecting statistical information. Lacks knowledge of some elements for representing statistical information in frequency tables. Lacks knowledge of some elements for representing statistical information in graphs.
Statistical data interpretation	Expresses valid conclusions based on the interpretation of statistical data. Makes inferences related to the interpretation of statistical data.	Identifies statistical data in tables or graphs. Interprets statistical data in graphs or tables.	Interpret some statistical data in graphs or tables. Identifies some statistical data in tables or graphs.	Has difficulty identifying statistical data in charts or graphs. Presents difficulty interpreting statistical data in graphs or tables.
Expression of valid conclusions from information presented in statistical data.	Expresses conclusions and inferences from information presented in statistical data.	Expresses valid conclusions from information presented in statistical data.	Expresses incorrect conclusions from information presented in statistical data.	Has difficulty expressing valid conclusions from the information presented in statistical data.
Justification with valid arguments of the decisions made based on information presented in statistical data.	Justifies decisions made based on information presented in statistical data with valid arguments before an audience	Justifies decisions made based on information presented in statistical data with valid arguments	Justifies decisions made based on information presented in statistical data with invalid arguments	Has difficulty justifying decisions made based on information presented in statistical data with valid arguments

Source: made by the author.

In this regard, the fifth and sixth weeks of the project were dedicated to data exploration, processing, interpretation and communication in the report. The following image synthetically shows an example of the construction of a frequency table presented in this stage and the feedback given according to the first criterion in the rubric.

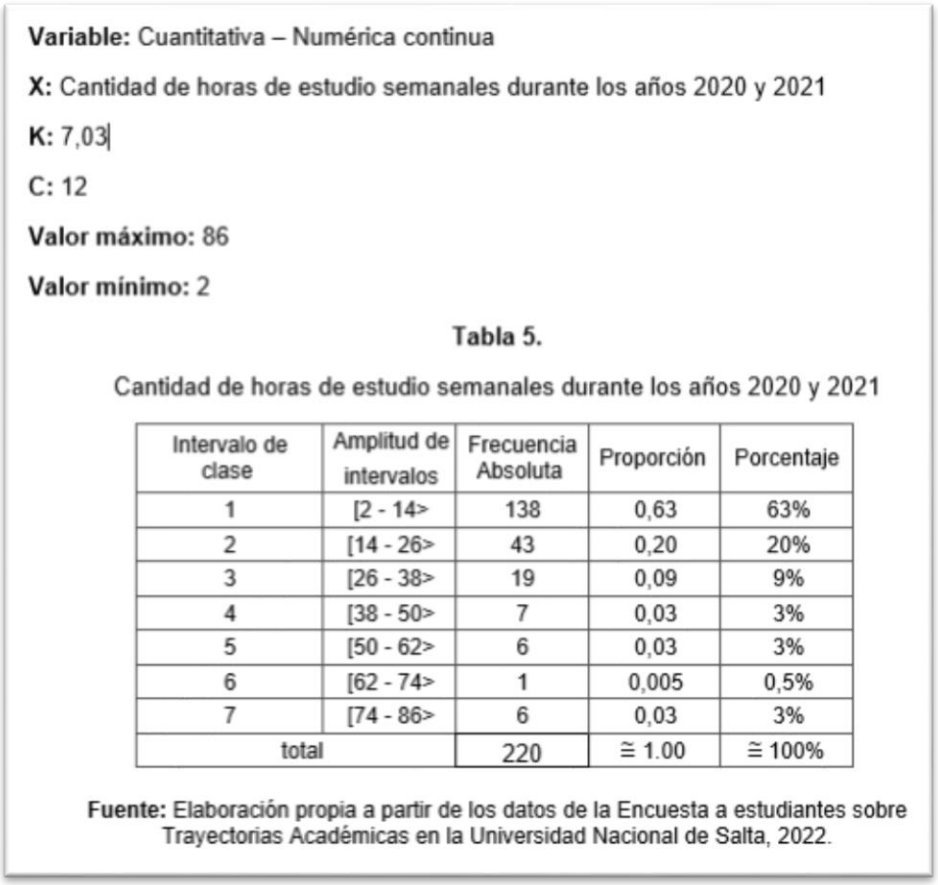
FIGURE 4 - Feedback on the first version of the report presented by group 4.



Intervalo de clase	Amplitud de intervalos	Frecuencia Absoluta	Proporción	Porcentaje
1	[2- 14]	149	0,68	68
2	[15- 27]	35	0,16	16
3	[28-40]	15	0,07	7
4	[41-53]	7	0,03	3
5	[54-66]	7	0,03	3
6	[67-79]	0	0	0
7	[80-92]	7	0,03	3
total		220	= 1.00	= 100%

Source: made by the author.

FIGURE 5 - Presentation of the final version of the report presented by group 4.



Variable: Cuantitativa – Numérica continua

X: Cantidad de horas de estudio semanales durante los años 2020 y 2021

K: 7,03

C: 12

Valor máximo: 86

Valor mínimo: 2

Tabla 5.

Cantidad de horas de estudio semanales durante los años 2020 y 2021

Intervalo de clase	Amplitud de intervalos	Frecuencia Absoluta	Proporción	Porcentaje
1	[2 - 14>	138	0,63	63%
2	[14 - 26>	43	0,20	20%
3	[26 - 38>	19	0,09	9%
4	[38 - 50>	7	0,03	3%
5	[50 - 62>	6	0,03	3%
6	[62 - 74>	1	0,005	0,5%
7	[74 - 86>	6	0,03	3%
total		220	≅ 1.00	≅ 100%

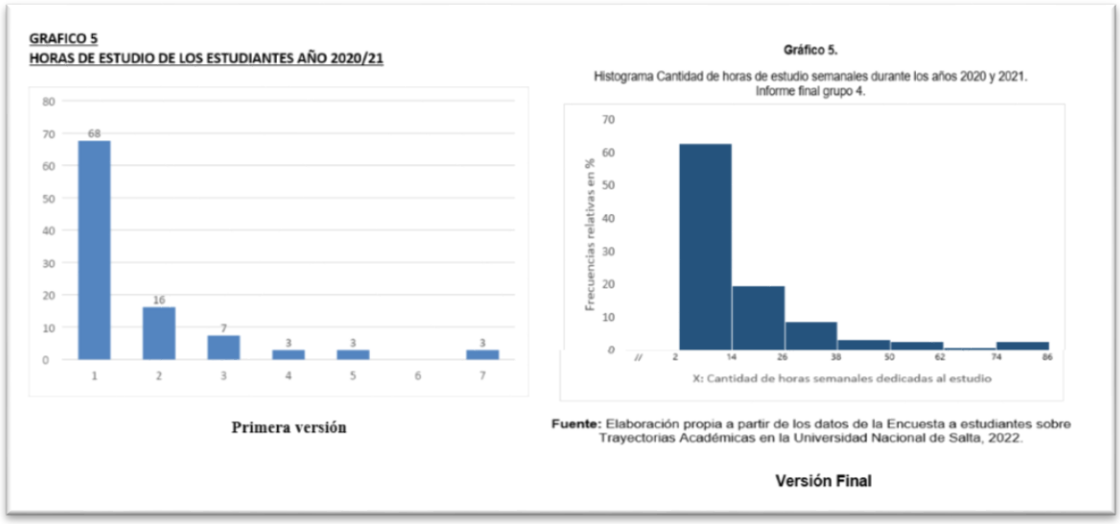
Fuente: Elaboración propia a partir de los datos de la Encuesta a estudiantes sobre Trayectorias Académicas en la Universidad Nacional de Salta, 2022.

Source: made by the author.

In the analysis stage, decisions were made about the techniques to be used for organizing, classifying and graphically and/or numerically describing the data set resulting from the measurement of each variable. These decisions are conceptually based. For this reason, students were asked to provide a brief justification of the statistical work performed within the body of the report.

In the proposed sequence, the conclusions phase allowed students to interpret the behavior of the data presented in tables, graphs and descriptive measures in relation to the question they wanted to answer. Figure 6 shows the adjustments made by one of the groups after the feedback provided during an in-person meeting. The feedback addressed aspects related to the type of graph appropriate for a continuous variable organized into class intervals as well as the structural elements of a graph (titles, labels, axes, scale, font).

FIGURE 6 - Graphical representation created by group 4.



Source: made by the author.

This final stage presented the greatest challenge for the students. In addition, in the drafts of their progress, some of them provided readings of the results without proper context or a consistent connection to the problem. Two cases are mentioned to illustrate this situation.

> "Considering a context of pandemic in the years 2020/21, we can observe from the graph we obtained based on data collection that the students from the Faculty of Natural Sciences spent 68% of their time studying between 2 and 14 hours in their respective homes." (Group 4)
>
> "The number of hours per week dedicated to studying by the students of the Faculty of Exact Sciences at UNSa, it can be observed that 48% devoted between 2 - 8 hours to studying, 24% 8 - 16 hours, 20% spent 16 - 24 hours and 8% dedicated 24 - 36 hours." (Group 15)

Formative feedback was a central component to intervene in this sense and contribute to the brief formulation of conclusions based on the results obtained, which is related to the second and third criteria of the rubric. The

following is the record of the reformulation made by one of the groups in the previous example.

> "The development of the partial assessment helped us understand the characteristics and study conditions of students during the pandemic (2020/2021). Regarding the time spent studying during that period, we observed that 68% of the sample of students from the Faculty of Natural Sciences devoted between 2 and almost 14 hours per week to studying, excluding virtual class hours. Meanwhile, 3% indicated that they had dedicated between 74 and 86 hours per week to studying. It can be observed that the largest percentage of students falls within the first and third intervals, representing 92% of cases that spent 38 hours or less studying." (Group 4)

The challenges of formative assessment in statistics

It is known that the way an assessment task is designed and organized has a profound influence on how students shape their study habits (Gibbs & Simpson, 2005). Thus, the implementation of the work sequence framed within the investigative cycle in statistics allowed us to experience how this process can help students take control of their own learning. As an example, excerpts from the final reflections on the experience of two groups are presented below.

> "This midterm assessment by the department was, from our point of view, a very enriching experience when it comes to applying the concepts learned in class to a research work. We had to perform a series of procedures, and maintain the necessary responsibility to be able to collect the required number of answers. This work brings us much closer to what our career as future educators entails, it was interesting to work in a different way, as a group, and outside the classroom context." (Group 4)

> "This led us to step out of the usual assessments we were used to and experience a new way of expressing the knowledge acquired during the course. At the same time, this assessment method required greater effort, but despite that, the process was interesting and enriching for us." (Group 15)

Of course, getting students to develop autonomy and self-regulation in their learning is a process that requires time, as well as having the necessary support or scaffolding in enriched environments of statistical knowledge construction experiences.

TABLE 2- Percentage of assignments based on the levels achieved by the groups in the rubric criteria. Statistics in education, 1st semester, 2022.

	EXCELLENT (4)	**VERY GOOD (3)**	**GOOD (2)**	**NOT MET (1)**
Representation of information in statistical tables and graphs	20%	50%	20%	10%
Statistical data interpretation	15%	50%	25%	10%
Expression of valid conclusions based on the information presented in statistical data.	8%	32%	40%	20%
Justification with valid arguments of the decisions made based on the information presented in statistical data.	10%	60%	20%	10%

Source: made by the author.

Conclusions

At the beginning of each academic period, the teaching team faces the challenge of building statistical meaning and thinking in students. For this purpose, it is recognized as necessary to promote a change in the perception of the field of knowledge and foster favorable dispositions for its learning. To navigate this journey, teaching strategies arising from problems or topics from real contexts were proposed in the classes. In this way, we sought to

engage students and demystify the idea that statistics is about abstractions without empirical reference.

One of the assumptions that students have about statistical data is a lack of trust in the information they provide due to their unfamiliarity with the ways in which they are constructed. The experience described represents a clear example of problematization of the subject. It involved experiencing an organic process that went from the conceptual design of the instrument, its application, analysis of data quality and cleanliness of the data, processing and communication of the results.

Adhering to the guidelines of formative assessment led to real-time adjustments in the teaching approach to address the individual needs and skills of each student. In addition, the incorporation of metacognition into the process of constructing information about a phenomenon of interest allowed the students to understand the difficulties, scope and limitations inherent in statistical work.

Based on what has been discussed, the question arises: Why approach this challenge through an assessment project? From the perspective of the teaching position, assessment is seen as an inherent part of teaching and should therefore be integrated into the educational process. Consequently, from the perspective of formative assessment, the partial assessment project was designed to define the competencies to be developed, observe them and provide feedback and support for their achievement. In this way, an effort was made to help students recognize their achievements and difficulties in their own learning processes.

This work allowed us to review the experience and the pedagogical decisions made throughout the project, identifying strengths such as increased student engagement in the proposed activities, a shift in the classroom dynamics, fostering curiosity and creativity to solve the proposed tasks, and promoting collaboration among peers. These aspects led to an improvement in the understanding of specific content within the

course's curriculum and the acquisition of communication skills in the field of statistics.

However, it is recognized that a assessment project like this requires a significant amount of time and the need to diversify spaces for its implementation. Nevertheless, it is considered that the implemented project not only generated conditions for the development of competencies linked to literacy, reasoning and statistical thinking, but also contributed to the retention and progress of students' academic paths.. For this reason, there is a commitment to its continuity.

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