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Effects of a training intervention on secondary school teachers' attitudes toward statistics

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ABSTRACT

In today's data-driven society, strong statistical literacy is essential for all citizens. Within the educational context, teachers play a crucial role in developing students' statistical competencies. However, pre-service teachers' attitudes toward statistics can impact how they approach its instruction. This study examines changes in future teachers' attitudes toward statistics before and after participating in a training intervention aimed at enhancing statistical literacy. An attitude questionnaire was administered to 41 pre-service secondary school teachers from two Chilean universities, both before and after the training intervention. Although the results showed an overall increase in mean scores after the training, this change was not statistically significant. Nevertheless, improvements were observed in pre-service teachers' perceptions of statistics as a fundamental tool for civic education, their ability to interpret statistical representations in the media, and their enjoyment of problem-solving. These results suggest that attitudes toward statistics could be positively influenced through targeted educational interventions, although the study's conclusions are limited by the relatively small sample size.

Keywords: statistical literacy, attitudes toward statistics, pre-service teachers

INTRODUCTION

In today's world, citizens must be able to interpret and understand large volumes of information and make informed decisions based on statistical concepts. To achieve this, statistical literacy must align with the demands of modern society (Gal, 2004), enabling individuals to better comprehend complex issues and actively engage in social life (Engel, 2017; Ridgway, 2022). Moreover, the literature emphasizes the role of non-cognitive factors, such as disposition and affect, in the development of statistical literacy (Bond et al., 2012; Gal, 2002, 2004). In this regard, beyond mastering statistical concepts, it is crucial to foster positive attitudes toward statistics, encouraging a deeper appreciation of and recognition for its societal significance (Wallman, 1993).

Given the importance of statistics, universities include statistics courses in education and social sciences programs (Ridgway et al., 2007). These courses generally focus on understanding statistical concepts. However, now there is a growing emphasis on addressing students' attitudes (Ramirez et al., 2012; Songsore & White, 2018), promoting a positive appreciation for statistics and its importance across various disciplines, and its relevance in everyday life (Huang et al., 2022; Leavy et al., 2019).

Although studies on attitudes toward statistics have gained significant attention, as reflected in a large body of research, studies focused on pre-service and in-service teachers are more limited (Groth & Meletiou-Mavrotheris, 2018). The available research underscores the need of analyzing teachers' attitudes, as these may influence their knowledge, their willingness to teach the subject (Leavy et al., 2013), and their students' attitudes toward statistics.

It is important to recognize that attitudes toward statistics are not static; as they can evolve during university studies (Millar & White, 2014; Paul & Cunningham, 2017). Therefore, it is necessary to implement statistics courses adapted to students' needs, promoting interest in and appreciation for statistics. The GAISE II guidelines (Bargagliotti et al., 2020) suggest focusing the teaching of statistics on conceptual understanding. This document includes:

- The importance of formulating questions during the process of solving statistical problems;
- Considering a variety of data types and variables, planning their collection, cleaning, and analysis;
- Incorporating multivariate thinking at all educational levels;

- The relevance of probability in quantifying randomness;
- Using technology in the teaching and learning of contemporary statistics;
- Communicating statistical information clearly and accurately;
- Emphasizing the role of assessment in the teaching and learning process.

In this context, the study aims to analyze the attitudes of pre-service secondary teachers (PSTs) toward statistics before and after participating in a training intervention designed to develop statistical literacy. Specifically, it seeks to answer the following research questions:

RQ1 What are the attitudes of PSTs toward statistics prior to participating in a training intervention focused on developing statistical literacy?

RQ2 Can the implementation of a training intervention aimed at enhancing statistical literacy influence a change in PSTs' attitudes toward statistics?

The following sections present the theoretical foundations that support this study, along with the methodology employed. Subsequently, the results are discussed. The paper concludes with an analysis of the findings, key conclusions, and the study's limitations.

THEORETICAL FRAMEWORK

Statistical Literacy

Statistical literacy has become increasingly important in society, as it plays a key role in shaping critical citizens, making it essential to develop this skill in classrooms. Gal (2002) argues that statistical literacy involves the ability to interpret and critically evaluate statistical information within its context, to construct data-based arguments, and to discuss or communicate statistical information. The development of statistical literacy encompasses the ability to comprehend statistical information alongside probability as a measure of uncertainty, organize data, and to construct various data representations. This requires a thorough grasp of key concepts, vocabulary, and symbols (Ben-Zvi & Garfield, 2004).

Gal (2004) proposes a model of statistical literacy composed of two interrelated components. The first component encompasses cognitive knowledge and consists of five key elements: literacy skills, statistical knowledge, mathematical knowledge, contextual knowledge, and critical thinking abilities. The second component focuses on dispositional aspects, such as critical interpretation, beliefs, and attitudes.

In higher education, the teaching of statistics is primarily focused on conceptual knowledge. However, it is crucial to foster statistical reasoning that enables students to apply this knowledge to broader social contexts (Daniel & Braasch, 2013; Ridgway, 2022). Therefore, statistical literacy is seen as a lifelong learning process (Davies, 2011). Educators face the challenge of designing instructional processes in engaging environments (Chick & Pierce, 2008), emphasizing conceptual comprehension while promoting the formulation and response to critical questions (Reston et al., 2006). Thus, it is vital to integrate the development of statistical literacy in teacher education at all levels.

Attitudes Toward Statistics

Attitudes toward statistics are defined by Gal et al. (1997) as "a summation of emotions and feelings experienced over time in the context of learning mathematics or statistics" (p. 5). Similarly, Estrada and Batanero (2008) describe them as a set of emotions and feelings that are encountered during the learning of a specific subject, particularly statistics.

A teacher's attitude toward statistics can significantly influence students' learning, as affective factors may hinder both the understanding and practical application of statistics beyond the classroom (Gal & Ginsburg, 1994). Estrada and Batanero (2008) point out that a teacher's negative attitude toward statistics could negatively impact their students, limiting their understanding and appreciation of the subject. According to Estrada et al. (2013), attitudes toward a subject like statistics tend to be stable, yet they can vary in intensity, ranging from positive to negative. These attitudes develop early in life; while they are generally favorable at first, they can shift to negative over time. Several factors contribute to the formation of attitudes toward statistics, including knowledge acquired outside the classroom, such as interpreting statistical information from the media or press; previous learning experiences in school, where traditional teaching methods may foster negative attitudes; and the association between statistics and mathematics, where attitudes toward one subject can influence attitudes toward the other.

Numerous studies (e.g., Schau et al., 1995; Songsore & White, 2018) suggest that attitudes toward statistics comprise three main components. The affective component relates to emotions and motivation regarding statistics classes and exams. The cognitive component encompasses beliefs and perceived abilities to learn statistics. The behavioral component refers to the willingness and disposition to engage with statistical learning. More specifically, Estrada et al. (2004) identify three pedagogical components of attitudes. The cognitive component pertains to conceptions and beliefs about statistics, the affective or emotional component is linked to the emotions and feelings that statistics elicits, and the behavioral component involves tendencies and dispositions toward using statistics in various contexts. These components collectively shape how individuals perceive, experience, and engage with statistics throughout their education and professional development. Additionally, the authors introduce other anthropological components of attitudes toward statistics. The social component reflects perceptions regarding the role of statistics in society, its usefulness for students, its integration into the curriculum, and its perceived difficulty. The

instrumental component, on the other hand, relates to the applicability of statistics in various fields, its role as a reasoning tool, and its broader cultural significance.

Research on attitudes toward statistics suggests that these attitudes are not fixed and can improve with targeted training (Alpízar et al., 2015). Thus, it is important to consider factors that may influence changes in attitudes (Leavy et al., 2019), such as the timing of instrument administration for measuring attitudes (Gal & Ginsburg, 1994), the integration of statistical investigative cycles through projects, and the use of cooperative learning strategies. Carnell (2008) notes that incorporating a project into a statistics course may not significantly impact students' attitudes; however, the author highlights the need for further research on this issue to better understand the effectiveness of such interventions.

Previous Research

In recent years, the study of attitudes toward statistics has generated significant attention internationally. Research in this field has primarily focused on developing and utilizing scales to measure these attitudes, with the most widely used instruments being the Attitude Toward Statistics scale (ATS) (Wise, 1985), the Statistics Attitude Survey (SAS) (Roberts & Saxe, 1982), and the Survey of Attitudes Toward Statistics (SATS) (Schau et al., 1995). These tools assess various components, including perceived difficulty, self-efficacy, anxiety, appreciation, and enjoyment. Moreover, additional studies have explored the impact of factors such as gender (Nasser, 2004), academic performance, and changes in attitudes following the completion of statistics courses or their instruction (Carnell, 2008; Leavy et al., 2019).

Leavy et al. (2019) examined the attitudes of 280 pre-service primary school teachers toward statistics, both before and after completing a course on teaching statistics. The study employed a revised version of the Survey of Attitudes Toward Statistics (SATS) (Schau et al., 1995) to measure changes. Results indicated that participants generally held positive attitudes toward the subject at the outset, while also acknowledging its perceived difficulty. Additionally, the findings suggest that these attitudes may shift in a positive direction following structured training within teacher education programs.

Estrada et al. (2004) introduced the Attitudes Toward Statistics Scale (EAEE), comprising 25 items, designed to assess the attitudes of teachers who teach statistics in a school setting. This scale was developed by combining elements from the most used scales: ATS (Wise, 1985), SAS (Roberts & Saxe, 1982), and the scale proposed by Auzmendi (1992). It was administered to a sample of 66 in-service teachers and 74 pre-service teachers in early childhood and primary education. The results indicated that both in-service and pre-service teachers held similar attitudes toward statistics, with in-service teachers showing slightly more favorable perspectives. However, attitudes appeared to decline when teachers were actively involved in teaching or applying statistics, emphasizing the ongoing challenges associated with the subject and the importance of strengthening teachers' statistical knowledge. The highest-rated items (with mean scores above 4.1 on a 5-point scale) were primarily linked to instrumental-affective, social-behavioral, and educational-cognitive components. In contrast, the lowest-rated items (with mean scores below 2.9) were associated with educational-affective, social-cognitive, and general educational dimensions. These trends point to specific domains where targeted interventions in teacher preparation programs may be warranted.

In a subsequent study, Estrada et al. (2013) applied the EAEE to a sample of 288 pre-service teachers from Spain (140 participants) and Peru (148 participants). The analysis revealed that three items displayed inadequate psychometric properties, resulting in a refined 22-item scale with high reliability from both a classical perspective and the Rating Scale model. In this sample, only one item aligned with the educational-cognitive dimension maintained a high mean score (above 4.1), while an item reflecting the instrumental-cognitive dimension remained among the lowest rated, with a mean score of 2.67-lower than the corresponding item mean in Estrada et al. (2004), which was 2.93.

On the other hand, Alpízar et al. (2015) conducted a study involving 20 primary school mathematics teachers, administering pre- and post-course questionnaires that included selected items from the EAEE. The goal was to assess potential shifts in attitudes toward probability and statistics following professional development. While results showed minor improvements in specific areas, overall response patterns remained consistent between the initial and final evaluations. In the pre-course questionnaire, the most and least favorably rated items corresponded to the social-cognitive and educational-cognitive components. Post-course questionnaire results showed continued low ratings for the same components, while the highest-rated items included one aligned with the social-cognitive dimension and another reflecting the educational-affective component. Although most participants recognized the importance of statistics for society and agreed that it should be taught in schools, they did not feel confident teaching it, likely due to insufficient training in the subject.

METHOD

This study adopted a pre-experimental design to examine the attitudes of PSTs toward statistics before and after participation in a training intervention. According to Hernández et al. (2014), this design involves the application of a pre-test and a post-test to a single group, without the objective of establishing causal relationships. To assess the quality of the instrument in both test applications, an item-level analysis was conducted following the classical perspective as proposed by Muñiz (2017). This approach assumes that an individual's observed score consists of a true score and a measurement error, and it provides analytical tools for evaluating the consistency and discrimination of test items. The following indices were used for item analysis: item mean and standard deviation, to examine response distribution; corrected item-total correlation, which assesses each item's discriminative capacity by correlating it with the total score excluding that item; Cronbach's alpha if item deleted, to determine the effect of each item on overall reliability; and p-value, to evaluate statistical significance in item response variation across pre- and post-test

conditions. This methodology aligns with standard practices for evaluating Likert-type scales in educational research, particularly within the domain of attitudes toward statistics.

Participants

The participants in this training intervention consisted of 41 PSTs from two Chilean universities (22 women and 19 men), all in their ninth semester of a ten-semester program. Notably, all participants had previously completed courses in statistics or research methodology.

Participation in the training was voluntary and offered as part of a supplementary workshop designed to develop statistical literacy. Participants were informed about the research objectives, and written consent was obtained for their involvement. To ensure anonymity, each participant was assigned a unique research code.

An attitude toward statistics scale was administered one week before the training intervention (pre-test) and again at its conclusion (post-test). To enhance the reliability of the findings, clear instructions on how to use the scale were provided before administering the instrument.

Instrument

The instrument used in this study was the Attitudes Toward Statistics Scale (EAEE) proposed by Estrada et al. (2004), a Likert scale with five response options: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). For this study, three items were excluded, as Estrada et al. (2013) found that they showed no significant correlation with the rest of the scale. The final version of the scale consisted of 22 items (**Table 1**). It is important to note that 14 items were phrased positively, while 8 were phrased negatively (items 1, 5, 8, 10, 13, 14, 18, and 22). To accurately interpret the results of negatively worded items, a high score corresponds to a negative attitude toward statistics. Therefore, the Likert scale scores for these items were inverted, meaning that Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), and Strongly Disagree (5) were used to reflect the reversed scoring. The distribution of the items according to the components they evaluate is presented in **Table 2**.

Table 1. Item analysis in pre-test and post-test questionnaire

Item	Classical indices								Value
	Pre-test				Post-test				
			The item is omitted				The item is omitted		
	Mean	St. deviation	Cor. item-total	Alfa	Mean	St. deviation	Cor. item-total	Alfa	P
Affective-Social									
1. I find the statistical information presented in some TV programs annoying.	3.10	1.30	-0.01	0.88	3.34	1.13	0.37	0.86	0.28
10. I feel intimidated by statistical data.	3.68	1.12	0.24	0.86	3.73	1.07	0.29	0.87	0.59
22. I avoid statistical information when reading.	3.80	1.05	0.25	0.86	3.85	1.08	0.37	0.86	0.78
Affective-Educational									
6. I enjoy classes where statistics is explained.	3.34	1.19	0.61	0.85	3.39	1.18	0.58	0.86	0.67
11. I find the world of statistics interesting.	3.56	1.09	0.69	0.85	3.71	1.14	0.70	0.85	0.32
Affective-Instrumental									
9. I like statistics because it helps me to better understand the complexity of certain topics.	3.51	1.16	0.78	0.85	3.68	0.85	0.76	0.85	0.12
12. I enjoy serious work that includes statistical studies.	3.68	1.21	0.59	0.85	3.85	1.01	0.58	0.86	0.38
15. I am passionate about statistics because it helps to see problems objectively.	3.51	1.02	0.51	0.86	3.51	0.87	0.63	0.86	1.00
19. I enjoy solving problems when using statistics.	3.17	1.18	0.79	0.85	3.61	0.94	0.61	0.86	0.00*
Cognitive-Social									
2. Statistics helps to understand today's world.	3.76	1.44	0.55	0.85	3.95	1.11	0.50	0.86	0.23
18. Statistics is only useful for people in the sciences.	4.24	1.17	0.21	0.87	4.27	1.02	0.31	0.87	0.88
Cognitive-Educational									
3. Statistics is essential in the basic education of future citizens.	3.93	1.08	0.59	0.85	4.12	0.84	0.73	0.85	0.04*
5. Statistics should not be taught in schools.	4.44	1.02	0.40	0.86	4.32	1.01	0.50	0.86	0.41
16. Statistics is easy.	2.93	0.84	0.05	0.87	3.05	0.83	-0.21	0.88	0.36
Cognitive-Instrumental									
21. Statistics helps to make more informed decisions.	4.02	1.06	0.56	0.85	3.93	1.05	0.61	0.86	0.44
Behavioral-Social									
8. I do not understand statistical information presented in the media.	3.59	1.04	0.23	0.86	4.00	0.94	0.39	0.86	0.01*
17. I understand election results better when they are presented with graphical representations.	4.12	1.05	0.42	0.86	4.05	0.99	0.49	0.86	0.68
Behavioral - Educational									
7. Statistical problems are easy for me.	3.02	1.06	0.60	0.85	3.17	0.94	0.28	0.87	0.39
14. I never understand what is being discussed in statistics lessons.	3.88	0.87	0.50	0.86	3.71	0.98	0.38	0.86	0.28
20. I often explain statistical problems to my classmates who didn't understand them.	2.71	1.12	0.52	0.86	3.22	1.06	0.34	0.87	0.00*

* Statistically significant difference

Table 1 (Continued). Item analysis in pre-test and post-test questionnaire

Item	Classical indices								Value
	Pre-test				Post-test				
			The item is omitted				The item is omitted		
	Mean	St. deviation	Cor. item-total	Alfa	Mean	St. deviation	Cor. item-total	Alfa	p
Behavioral - Educational									
4. I use statistics to solve everyday problems.	3.32	1.05	0.51	0.86	3.61	1.09	0.56	0.86	0.05
13. I rarely use statistics outside of university.	2.73	1.36	0.26	0.87	3.07	1.03	0.15	0.87	0.10

* Statistically significant difference

Table 2. Components of the attitudes toward statistics scale (EAEE)

Pedagogical component	Anthropological Component		
	Social	Educational	Instrumental
Affective	1, 10, 22	6, 11	9, 12, 15, 19
Cognitive	2, 18	3, 5, 16	21
Behavioral	8, 17	7, 14, 20	4, 13

Training Intervention

The design of the intervention incorporated several aspects suggested by the GAISE II report (Bargagliotti et al., 2020), aimed to promote the development of statistical literacy, while also fostering more positive attitudes toward statistics. The session also followed the PPDAC cycle (problem, plan, data, analysis, conclusion) proposed by Wild and Pfannkuch (1999) to facilitate the teaching of statistics through projects.

As part of the training, a reinforcement of statistical knowledge was provided, recognizing that PSTs required a solid foundation in the subject for their professional growth. To emphasize the understanding of statistical concepts over calculation procedures, a brief introduction to the R and RStudio software was included. R was chosen due to its open-source nature and its ability to facilitate flexible and efficient data management (Gould, 2005).

The training intervention lasted four hours, was conducted by the authors, and comprised the following stages:

1. A review of fundamental statistical concepts, including data, types of variables and scales, data representation (tables and statistical graphs), measures of central tendency and dispersion, as well as correlation and regression.
2. An introduction to R and RStudio software was provided, along with its programming language, which enables statistical analysis and data visualization. Participants were given a dataset from the educational context, containing various types of variables (e.g., attendance, grades, gender, age), as well as a series of practical exercises (e.g., calculating statistical measures, constructing different types of graphs) to complete in RStudio. To emphasize conceptual understanding, the results of these exercises were interpreted within the context of the data.
3. Participants formed self-selected teams of three members and were assigned a dataset on the characteristics of a set of animals, which included different types of variables (e.g., species, weight, diet, height, life expectancy). Specifically, they were asked to complete the following activities:

   a. Formulate a question based on the information provided.

   b. Summarize the data using frequencies and statistics based on the studied variable.

   c. Present the data using frequency tables and graphs.

   d. Draw conclusions from the data.
4. Upon completing these activities, participants also completed the post-test questionnaire (EAEE). Additionally, to gather feedback on the training intervention, an open-ended question was included: What aspects of the training intervention do you consider positive?

RESULTS

To evaluate the fit of each item and allow for more detailed comparisons, **Table 1** presents the results for each of the 22 items, as they were administered to participants in both the pre-test and post-test questionnaires. To analyze the items in both the pre-test and post-test, the following indices were used, as in Estrada et al. (2013): mean, standard deviation, item-total correlation with the item removed (which indicates the item's discriminating ability), and Cronbach's alpha without the item, providing a measure of the scale's reliability excluding that item. Regarding the means and standard deviations, they were calculated based on the scores given in the responses.

The reliability of the instrument was assessed using Cronbach's alpha coefficient. The analysis yielded an alpha value of approximately $\alpha = 0.87$ for both the pre-test and the post-test, indicating a high degree of internal consistency.

In the affective-social component, item 1 showed an insignificant and ignorable correlation, as its value was below 0.15 and near-zero. For items 10 and 22, the mean increased in the post-test; however, this difference was not statistically significant. A

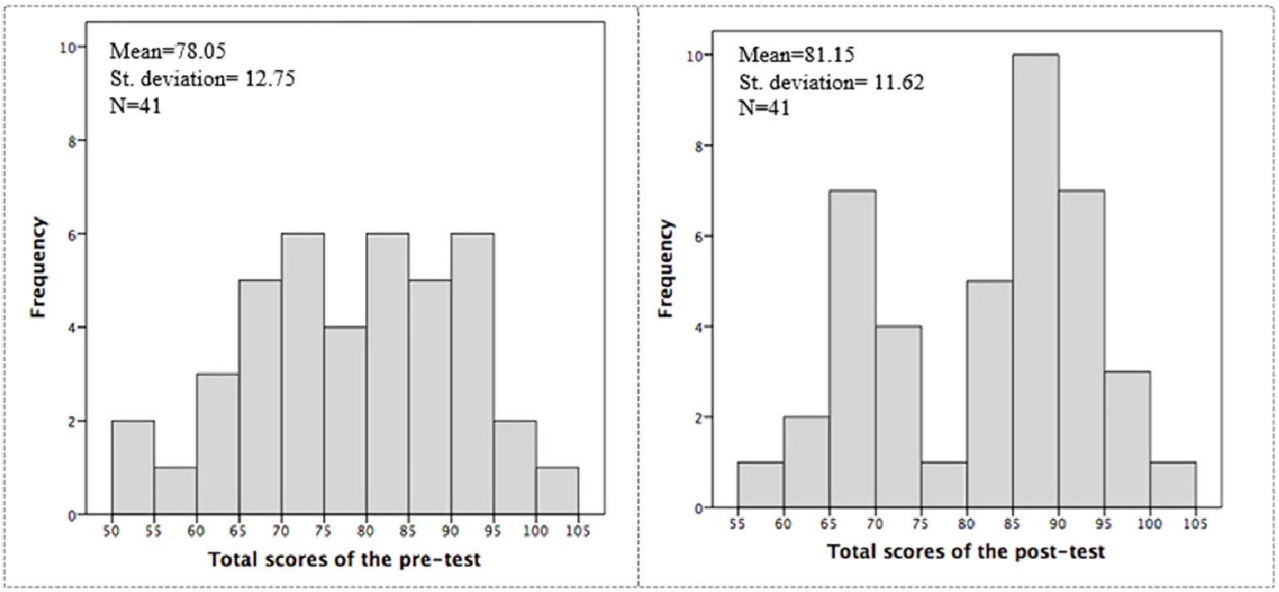

Figure 1. Frequency distribution of total scores in pre-test and post-test questionnaires (Source: Authors' own elaboration)

similar pattern was observed for items 6 and 11 in the affective-educational component. Regarding the affective-instrumental component, items 9 and 12 showed an increase in their mean scores in the post-test, but this difference was not statistically significant. Item 15 maintained the same mean score in both the pre-test and post-test, while item 19 showed a statistically significant increase in the post-test mean.

In the cognitive-social component, items 2 and 18 received high ratings, and while their mean scores increased in the post-test, the differences were not statistically significant. Notably, item 18, which was negatively phrased, indicated a shift in perception, suggesting that PSTs believe that statistics is not only useful in scientific fields but also valuable for society in general.

In the cognitive-educational component, item 3 showed a statistically significant increase in the post-test mean. For item 5, which was negatively phrased, the difference in mean scores was not statistically significant; however, it received a high rating, suggesting that PSTs believe that statistics should be taught in schools. Item 16 showed no significant correlation with the rest of the scale. Within the cognitive-instrumental component, item 21 did not show a statistically significant difference between pre-test and post-test mean scores; however, it received high ratings in both assessments, suggesting that PSTs hold a positive perception of the role of statistics in decision-making.

In the behavioral-social component, item 17 received high ratings, though a slight decrease was observed in the post-test, indicating that PSTs maintain a positive perception of the usefulness of graphs for interpreting information, such as election results. For item 8, which was negatively phrased, the mean increased with a statistically significant difference, suggesting that PSTs felt they had improved their ability to understand statistical information in the media. In the behavioral-educational component, item 7 showed an increase in the post-test mean, although this difference was not statistically significant. In item 14, which was negatively phrased, a slight decrease in ratings was observed in the post-test; however, this difference was not statistically significant. In contrast, item 20 showed a statistically significant increase in the post-test mean. Finally, the behavioral-instrumental component, item 13, which was negatively phrased, showed an increase in the post-test mean; however, this difference was not statistically significant, like item 4.

Regarding the overall results, **Figure 1** presents the frequency histograms for the total scores of the pre-test (left) and post-test (right) questionnaires for the entire sample. Since a score of 66 represents neutrality in both questionnaires, it can be asserted that the participants' overall attitudes toward statistics were positive. In the pre-test, scores ranged from 50 to 101 points, with only 8 participants scoring below 66. Most participants exhibited a positive attitude, with three modes (71, 78, and 88) and an average score of 78.05. In the post-test, scores ranged from 58 to 103 points, with an average score of 81.15, indicating an increase in overall scores compared to the pre-test. Although the mode shifted to 66, representing neutrality, only three participants scored below this value, suggesting a general trend toward improved attitudes following the training intervention. However, when the Mann–Whitney U test was applied to compare total scores from the pre-test and post-test, the result was $U = 718.5$ with a significance value of $p = .26$. This indicates that the observed increase in scores was not statistically significant at the conventional threshold.

In the open-ended question, *what aspects of the training intervention do you consider positive?* the word cloud presented in **Figure 2** highlights key themes. Notably, learning to program in R, the didactic approach of the training, and data analysis were the most frequently mentioned aspects. Furthermore, the repeated mention of "enjoyment" in learning to use R and "analyzing" data suggests that when PSTs engage with practical and relevant problems, their opinions toward statistics can improve. Additionally, the emphasis on the didactic aspect underscores the importance of a supportive and engaging learning environment that fosters confidence and active participation. This suggests that a training intervention closely aligned with the teaching profession, focusing on solving concrete problems, can help promote positive attitudes toward statistics. This is reflected in the word cloud, where terms such as "enjoyment," "analysis," "delivery," and "didactic" stand out as key elements of the intervention.

Figure 2. Word cloud of participants' opinions on the most interesting aspects of the training intervention (Source: Authors' own elaboration)

DISCUSSION

Among the main findings from the item-by-item analysis in the pre-test and post-test, item 5, which is negatively phrased within the cognitive-educational component, recorded high mean scores, indicating a positive attitude. This result aligns with the findings of Estrada et al. (2004, 2013), where PSTs consistently disagreed with the statement and expressed a strong belief that statistics should be taught in schools. A similar pattern was observed with item 18, within the cognitive-social component, another negatively worded item, which suggests that PSTs consider statistics useful for society. However, the mean scores for this item in Estrada et al. (2004, 2013) were lower than those found in this study.

Item 17, within the behavioral-social component, also received high mean scores, consistent with the findings of Estrada et al. (2004), as it reflects a behavioral disposition toward statistics. In general, most items were rated positively, considering that a score of 3 represents a neutral position and most items had mean scores above this threshold. However, some items showed less favorable results. For example, the mean scores for item 20 within the behavioral-educational component in both the pre-test and post-test differed from those reported in Estrada et al. (2004), where the mean was significantly higher (4.06). Similarly, item 13, a negatively phrased statement within the behavioral-instrumental component, received lower scores than those compared to those reported in Estrada et al. (2004, 2013). However, it is worth noting that both items showed an increase in their mean scores in the post-test.

Item 3, within the cognitive-educational component, showed a statistically significant increase in the post-test mean score, a result that aligns with the findings of Alpízar et al. (2015), where a similar improvement was reported. Item 8, within the behavioral-social component, which is negatively phrased, reached a significantly higher mean score in the post-test, in contrast to the results from Alpízar et al. (2015), where much lower mean scores (2.4 and 2.2) were reported. Similarly, item 19, within the affective-instrumental component, showed a significant improvement in this study, as was also observed in Alpízar et al. (2015).

These findings suggest an overall improvement in post-test scores though statistically not significant and align with some of the results reported by Alpízar et al. (2015), although their study did not include the development of a research project in the training provided to primary school teachers. These results are in line with those of Carnell (2008), who found no significant changes in attitudes. It is worth noting that although Carnell's study had a sample size comparable to this one, the use of a different attitude scale and the integration of the research project within a specific course may account for this discrepancy.

Furthermore, participants' reflections on the most engaging aspects of the training intervention indicate that it increased their interest in statistics and introduced them to technological tools that enable efficient and flexible data management, such as R and RStudio (Gould, 2005). The emphasis placed on these aspects suggests a positive shift in attitudes toward statistics, as PSTs increasingly recognize the value of technology in mathematics education (Bright et al., 2024), particularly in the context of data analysis (da Ponte & Noll, 2018).

CONCLUSIONS

This study analyzed the attitudes of PSTs toward statistics both before and after participating in a training intervention designed to develop statistical literacy and foster positive attitudes toward the subject. Investigating PSTs' attitudes toward statistics is particularly relevant, as these attitudes may influence their students' learning experiences (Estrada & Batanero, 2020).

A total of 41 PST from two Chilean universities participated in the training intervention. The design incorporated key elements from GAISE II (Bargagliotti et al., 2020), the phases of the PPDAC cycle (Wild & Pfannkuch, 1999) for statistical studies, and the use of R and RStudio software for data analysis.

A pre-experimental study was conducted using the EAEE scale (Estrada et al., 2004) to assess PSTs' attitudes toward statistics, as this instrument effectively evaluates teachers' perspectives on statistics in school settings.

Regarding **RQ1** participants generally evidenced moderate to positive attitudes in the pre-test questionnaire, with an overall mean score above the theoretical position of neutrality. These findings partially align with the results of Estrada et al. (2004, 2013). The highest-rated items corresponded to the cognitive component, as most participants recognized the importance of teaching statistics in schools (cognitive-educational), its relevance to society (cognitive-social), and its significance in decision-making (cognitive-instrumental). Additionally, participants expressed a better understanding of information when presented through graphical representations (behavioral-social). However, the lowest-rated items were within the behavioral component, particularly those related to using statistics outside the university setting (behavioral-instrumental) and explaining statistical problems to peers (behavioral-educational), suggesting potential gaps in participants' confidence in applying statistics.

Regarding **RQ2** although no statistically significant overall change in scores was observed, the results indicated an increase in the mean total scores on the post-test questionnaire. The most notable increases were found in attitudes related to recognizing statistics as essential in basic education (cognitive-educational), understanding statistical information presented in the media (behavioral-social), and enjoying problem-solving through statistics (affective-instrumental). These attitudes were already rated highly in the pre-test and improved further in the post-test. Additionally, the ability to explain statistical problems to peers (behavioral-educational) also showed improvement following participation in the training program.

These findings, in line with Leavy et al. (2019), suggest that pre-service teachers' attitudes toward statistics could be positively influenced through targeted training initiatives that foster statistical literacy. Addressing these attitudes is critical, as they represent a key dimension of statistical literacy, as emphasized by Gal (2004)

Among the main limitations of this study are the small sample size and the dual role of the researchers as both investigators and instructors in the training intervention, which may limit the generalizability of the findings to broader educational contexts.

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Ethical statement: The authors stated that the study was approved by the institutional ethics committee of University of Los Lagos on October 22, 2024 (Approval code: ORD 55/2024). Participants were informed that this study has educational objectives that are not rooted in economic or political processes, and they voluntarily agreed to participate. The authors further stated that each preservice teacher voluntarily answered the online questionnaire. To this end, a consent letter was given to the preservice teacher to inform them about the objective and procedure of the study, as well as to guarantee the privacy and confidentiality of the participants' data.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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