Estrategia pedagógica para desarrollar actitudes favorables en la enseñanza de la estadística en estudiantes de la licenciatura en Ciencias Ambientales

Pedagogical strategy to develop favorable attitudes in the teaching of statistics in students of the degree in Environmental Sciences

Estratégia pedagógica para desenvolver atitudes favoráveis ao ensino da estatística em alunos da licenciatura em Ciências Ambientais

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Resumen

Las actitudes negativas hacia el aprendizaje de la estadística por parte de los estudiantes de nivel licenciatura influyen en el rendimiento de su aprendizaje. Estudiar estas actitudes hacia el aprendizaje de la estadística es de suma importancia para comprender el fenómeno. En ese sentido, el objetivo de la investigación fue analizar las actitudes hacia el aprendizaje y los conocimientos elementales de la estadística de estudiantes de la licenciatura en Ciencias Ambientales; con base en los resultados, se seleccionó y utilizó una estrategia pedagógica pertinente que orientó el proceso de aprendizaje en la unidad de aprendizaje de Estadística. El método utilizado fue de tipo mixto, pues se aplicó una encuesta cuantitativa (con escala tipo Likert), así como un instrumento de preguntas abiertas (parte cualitativa). Luego, se aplicó una propuesta de intervención para el desarrollo de actitudes positivas de los estudiantes hacia la estadística. El análisis de la información cuantitativa fue con el paquete estadístico SPSS 21.0. y Excel. Las preguntas abiertas se analizaron con base en el método de codificación y clasificación. En cuanto a los participantes, se llevó a cabo un muestreo no probabilístico por conveniencia e intencional a alumnos de la Escuela Superior de Ciencias Ambientales de la Universidad Autónoma de Guerrero.

Los resultados muestran que los estudiantes que llevaron el curso de estadística con la estrategia pedagógica implementada aprenden más en clases, pues se promovió el aprendizaje autónomo. Además, reconocieron la estrategia implementada como una herramienta que puede articularse en el desarrollo de cualquier unidad de aprendizaje. Asimismo, se evidenció motivación en ellos para el desarrollo de actitudes positivas hacia el aprendizaje de la estadística. Este tipo de iniciativas pedagógicas favorecen el pensamiento reflexivo de las actitudes hacia las estadísticas y ayudan a promover la construcción de conocimientos para intervenir y resolver problemas. Como conclusión, podemos decir que, en general, la percepción de los estudiantes frente a este tipo de estrategia fue muy buena; sin embargo, se deben tomar en cuenta otros factores que surgen en el aula (cansancio, pereza, etc.) para mejorar la ejecución de la estrategia.

Abstract

Negative attitudes towards the learning of statistics by undergraduate students influence the performance in their learning. Studying these attitudes towards learning statistics is of great importance so as to understand the phenomenon. In this sense, the objective of the research was to analyze the attitudes towards learning and the elementary knowledge of the statistics of students of the Degree in Environmental Sciences, based on the results, a pertinent pedagogical strategy was selected and used, the same which guided the process of learning in the Statistics Learning Unit. The method used was of a mixed type, the quantitative Likert-type survey was applied and in the qualitative part an instrument of open questions was used, in addition, an intervention proposal was made, for the development of positive attitudes of the students towards the statistics. The analysis of the quantitative information was done with the statistical package SPSS 21.0. and Excel, developing only descriptive analysis, for open questions, it was based on the method of coding, classification. Intentionally and for convenience a non-probabilistic sampling was carried out to students of the Higher School of Environmental Sciences of the Autonomous University of Guerrero.

The results show that the students who took the statistics course with the pedagogical strategy implemented learn more in class, promoting autonomous learning and recognized the strategy as the tool that can be articulated in the development of any learning unit. They also showed motivation for the development of positive attitudes towards learning statistics. On the other hand, they contribute to promote reflective thinking of attitudes towards statistics, having greater emphasis on the construction of knowledge that allows them to intervene and solve problems through this Project-Based Learning pedagogical strategy which was proposed. As a conclusion we can say, that the perception of the students working with this type of pedagogical strategy is really good, however; fatigue, laziness, etc in the classroom.), are some factors that must be taken into account, this would allow to have a better execution of the proposed pedagogical strategy.

Keywords: student attitude, statistics, learning method.

Resumo

Atitudes negativas em relação à aprendizagem de estatística por alunos de graduação influenciam seu desempenho de aprendizagem. Estudar essas atitudes em relação ao aprendizado de estatísticas é de extrema importância para compreender o fenômeno. Nesse sentido, o objetivo da pesquisa foi analisar as atitudes frente à aprendizagem e conhecimentos elementares de estatística de alunos do curso de Ciências Ambientais; Com base nos resultados, foi selecionada e utilizada uma estratégia pedagógica pertinente que norteou o processo de aprendizagem na unidade de aprendizagem de Estatística. O método utilizado foi do tipo misto, uma vez que foi aplicada uma pesquisa quantitativa (com escala do tipo Likert), bem como um instrumento de questões abertas (parte qualitativa). Em seguida, foi aplicada uma proposta de intervenção para o desenvolvimento de atitudes positivas dos alunos em relação à estatística. A análise das informações quantitativas foi com o pacote estatístico SPSS 21.0. e Excel. As questões abertas foram analisadas com base no método de codificação e classificação. Em relação aos participantes, foi realizada uma amostragem não probabilística por conveniência e intencional para alunos da Escola Superior de Ciências Ambientais da Universidade Autônoma de Guerrero.

Os resultados mostram que os alunos que fizeram o curso de estatística com a estratégia pedagógica implementada aprendem mais em sala de aula, uma vez que foi promovida a aprendizagem autônoma. Além disso, reconheceram a estratégia implementada como uma ferramenta que pode ser articulada no desenvolvimento de qualquer unidade de aprendizagem. Da mesma forma, foi evidenciada neles motivação para o desenvolvimento de atitudes positivas em relação à aprendizagem estatística. Este tipo de iniciativas pedagógicas favorecem o pensamento reflexivo sobre as atitudes em relação à estatística e ajudam a promover a construção de conhecimentos para intervir e resolver problemas. Concluindo, podemos dizer que, em geral, a percepção dos alunos sobre este tipo de estratégia foi muito boa; entretanto, outros fatores que surgem em sala de aula (cansaço, preguiça, etc.) devem ser levados em consideração para melhorar a execução da estratégia.

Palavras-chave: atitude do aluno, estatística, método de aprendizagem.

Introduction

All research work starts from a problem to which it is sought to offer a solution proposal. In this sense, since the eighties, research in statistical education has considered the main objective of training human resources that appropriately use statistical thinking (Schau, 2003). However, there are affective factors that negatively influence the construction of statistical knowledge, such as feelings, values and attitudes towards this area or discipline (Torres, Aparicio, Bazán & Abdounur, 2015). Research carried out by Cardoso, Cerecedo and Ramos (2012), Gómez-Chacón (2000) and Gil, Guerrero and Blanco (2006) point out that some variables such as the taste for numbers can often negatively influence students. Likewise, Gil et al. (2006) indicate that certain students during their academic life manifest negative attitudes towards mathematics-statistics, which becomes a source of frustration, discouragement and anguish. For their part, Comas, Martins, Nascimento and Estrada (2017) found in an investigation carried out on university students that attitudes in general are moderate or positive in students, and indicate that having previous studies in statistics affects attitude, although - as It is stated by Salinas and Mayén (2016) - the global attitude towards statistics worsens with the years of study. In the study carried out by Salinas and Mayén (2016) in five schools of the College of Sciences and Humanities of the National Autonomous University of Mexico (UNAM) it is indicated that students recognize the importance and usefulness of statistics mainly in their area of study , as well as in daily life, and they point out that the lack of previous studies in this area can generate a favorable attitude towards this matter. For their part, Bautista, Morales ,dórame and Peralta (2016), in a sample of 392 students from different careers at the University of Sonora, indicate that the majority of students consulted assume a positive attitude towards statistics.

Likewise, the research work carried out by Sánchez (2019) —with students from two undergraduate programs in Mathematics, from the Autonomous University of San Luis Potosí and the Benemérita Autonomous University of Zacatecas— refers to the utility factor, made up of the questions 1, 6, 11, 16, 20 and 21 of the Auzmendi survey. This factor was integrated with the following statements: I consider statistics as a very necessary subject in the career, I want to have a deeper knowledge of statistics, knowing how to use statistics will increase my job possibilities, and for my professional development career one of the most important subjects to be studied is statistics. In short, the aforementioned author found that the majority of students have a favorable attitude towards statistics and show an interest in

learning it exhaustively. Likewise, for the same author, with the anxiety factor, questions 2, 7, 12, 17 and 22 are constituted, which are the following: the subject of statistics is quite bad for me, statistics is one of the subjects that most I'm afraid, when faced with a statistical problem I feel unable to think clearly, working with statistics makes me very nervous, and statistics make me uncomfortable and nervous. Sánchez found that about 30% of the students disagree with question 2, and that the majority of the students do not agree that statistics is one of the most feared subjects (question 7). On the other hand, with question 12, the majority of the sample divided their response neutrally and in disagreement, and question 17, in this case, found that 1 in 2 students does not feel nervous when working with statistics. In the same way, Sánchez (2019) found in his research on the trust factor, that most of the students answered in a neutral way on question 8; for question 13, most students feel calm when working with a statistical problem. Likewise, for question 18 the majority agree with this question. For the pleasure factor, Sánchez (2019) found on question 4 an unfavorable attitude towards statistics. With question 9, students generally do not enjoy talking to other statistics. Likewise, for question 14, according to Sánchez, an unfavorable attitude of students towards statistics could be predicted. Furthermore, for question 19 he highlights that 1 in 5 students disagrees that they would like to have an occupation in which they would have to use statistics.

Finally, with the motivation factor, made up of questions 5, 10, 15, 20 and 25, Sánchez (2019) found the following: most students consider that statistics is not too theoretical to be useful, but they consider which is useful for the professional who is not dedicated to research, and are motivated to use statistics in professional life. Regarding the anxiety factor, in a study carried out by García, Escalera, Moreno and Santana (2016) to students of the Center for Industrial and Services Technological Studies No. 15 in the City of Veracruz, it was shown that this factor prevents students achieve good performance in the learning process. Finally, Rodríguez's research (2011) indicates that students in humanistic careers have negative attitudes towards statistics, while those in non-humanistic careers have positive attitudes. Likewise, it is pointed out that the opinion about the usefulness in the profession of the students influences, since it is necessary to explain the usefulness and importance of this subject. Therefore, it is necessary to teach students statistical tools according to the information that they must process in the investigations they develop within the area of environmental sciences. Due to the aforementioned, the present work aimed to analyze the attitudes towards learning and elementary knowledge of statistics in students of the degree in

Environmental Sciences. Then, based on the results, a relevant pedagogical strategy was selected and used to guide the process and reduce the learning gap in the Statistical learning unit of the Higher School of Environmental Sciences of the Autonomous University of Guerrero. The questions that allowed answering the objective of the study were the following:

1. How to evaluate at the beginning and at the end of the course the learning of the students of the degree in Environmental Sciences so that they have positive attitudes towards the Statistics learning unit?

2. How to evaluate the degree of compression of the elementary knowledge of statistics that students of the degree in Environmental Sciences have?

3. How can students of the degree in Environmental Sciences have positive attitudes towards statistics?

Method

In the present research work a mixed type method was used (Hernández, Fernández & Baptista, 2014), since it was considered that the combination of quantitative and qualitative techniques would be the most appropriate to respond to the objective of the research.

Data collection instruments
Quantitative instrument

For the quantitative part of this research, the quantitative survey by Auzmendi (1992) was used, which consisted of 25 items that offered 5 options according to a Likert scale (1 = totally disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree). First survey. The factors measured in the 25 items focused on utility (items 1, 6, 11, 20 and 21), anxiety (2, 7, 12, 17 and 22), confidence (3, 8, 13, 18 and 23), liking (4, 9, 14, 19 and 24) and motivation (5, 10, 15, 20 and 25). In the utility factor, the importance, knowledge, satisfaction and mastery of statistics for the future professional were evaluated. In the anxiety factor, fear, mistrust and insecurity towards statistics in their training were assessed. The trust factor evaluated the positive attitude towards statistics. The liking factor focused on the taste for studying statistics. Lastly, the motivation factor focused on the negative attitude (disinterest) towards statistics. The statements that made up the Auzmendi survey are detailed below

(Table 1). Likewise, to obtain information on the cognitive aspects of the students after taking the course, the survey by Ayuga, González, Grande and Martínez (2012), modified for this work, was applied and was answered by 51 students (third survey). The fourth survey was on the perception of the use of the ABP pedagogical strategy (Rodríguez and Cortés (2010), answered by 52 students.

Tabla 1. Enunciados que conformaron el instrumento cuantitativo (encuesta de Auzmendi)

1. Considero a la estadística como una materia muy necesaria en la carrera
2. La asignatura de Estadística se me da bastante mal
3. El estudiar o trabajar con la estadística no me asusta en absoluto
4. El utilizar la estadística es una diversión para mí
5. La estadística es demasiado teórica como para ser de utilidad práctica para el profesional medio
6. Quiero llegar a tener un conocimiento más profundo de la estadística
7. La estadística es una de las asignaturas que más temo
8. Tengo confianza en mí mismo/a cuando me enfrento a un problema de estadística
9. Me divierte el hablar con otros de estadística
10. La estadística puede ser útil para el que se dedique a la investigación, pero no para el profesional medio
11. Saber utilizar la estadística incrementaría mis posibilidades de trabajo
12. Cuando me enfrento a un problema de estadística me siento incapaz de pensar con claridad
13. Estoy calmado/a y tranquilo/a cuando me enfrento a un problema de estadística
14. Estadística es agradable y estimulante para mí
15. Espero tener que utilizar poco la estadística en mi vida profesional
16. Para el desarrollo profesional de nuestra carrera considero que existen otras asignaturas más importantes que la estadística
17. Trabajar con la estadística hace que me sienta muy nervioso/a
18. No me altero cuando tengo que trabajar en problemas de estadística
19. Me gustaría tener una ocupación en la cual tuviera que utilizar la estadística
20. Me provoca una gran satisfacción el llegar a resolver problemas de estadística
21. Para el desarrollo profesional de mi carrera una de las asignaturas más importantes que ha de estudiarse es la estadística
22. La estadística hace que me sienta incómodo/a y nervioso/a
23. Si me lo propusiera creo que llegaría a dominar bien la estadística
24. Si tuviera oportunidad me inscribiría en más cursos de estadística de los que son necesarios
25. La materia que se imparte en las clases de estadística es muy poco interesante

Fuente: Elaboración propia

Qualitative instrument

To obtain qualitative data, the semi-structured survey method with open questions (second survey) was used. This consisted of a list of 9 questions to show prior knowledge when taking the statistics course on: utility, skills and attitudes towards statistics; in this way, we tried to collect more data to generate a better interpretation.

Semi-structured survey questions

1. What is statistics for you? Why?
2. Have you ever taken a statistics course? How did you find it? Did you like it? Why?
3. Do you find statistics very complicated or is it easy for you? Why?
4. Do you think this statistics course will be useful for your profession or will it be a waste of time? Why?
5. What skills would you like to acquire with this learning unit?
6. What are your expectations of this course regarding the teacher?
7. Do you have any difficulties to carry out the activities proposed by the teachers in the classes? Which are? Why?
8. So far, what are the biggest life lessons your academic education has taught you?
9. What three things can you do to improve your learning this year?

Participants

A non-probabilistic sampling was carried out for convenience and intentional (Lind, Marchal and Mason, 2004; Izcara, 2014; Otzen and Manterola, 2017) to the third semester students who were studying the Statistics learning unit. The population was 76 students (group 301, 43 students and group 302, 33 students) aged between 19 and 22 from the Higher School of Environmental Sciences of the Autonomous University of Guerrero, Llano Largo campus, Acapulco, Guerrero. It is worth noting that the participants were two groups 301 and 302 of which only 56 students answered, the quantitative instrument made up of 25 items from the Auzmendi survey, before taking the statistics course. Only 42 students answered the second phase of the application of the same instrument (after taking the course). The semi-structured survey of 9 open questions was answered only by 56 students, which was a diagnosis prior to the statistics course. The third survey was answered by 51 students, to show

cognitive aspects and the fourth survey on the perception of the use of the PBL pedagogical strategy, was answered by 52 students.

Data analysis methods

For the analysis of quantitative data, the statistical package SPSS (version 21.0) and Excel were used, which were used to generate descriptive tables and graphs according to the established analysis criteria. The qualitative information obtained with the open questions was analyzed using the coding method (Rincón, 2014).

Description of the implementation of the pedagogical strategy

The implementation of the pedagogical strategy was carried out from August 27, 2018 to July 15, 2019 during school hours in groups 301 and 302. The students worked with the pedagogical strategy, for which each team chose a topic to work on. class; of this topic, then they did a practical project. In the design of the project and in the implementation of the pedagogical strategy, the following phases were proposed, according to the project development scheme of Batanero and Díaz (2011) described below:

Statement of a practical problem

The students raised a practical problem in their daily environment (Batanero and Díaz, 2011; García and Guerrero, 2011; Jonassen, 1997). In this phase the student chose the content of his project from among the different topics that were worked on in the Statistics learning unit.

Approach of the research questions

The students identified a problem and subsequently proposed solutions from different perspectives (Flores and Juárez, 2017). Parallel to these activities, they worked in class, where they were guided and applied concepts, techniques from the topics of descriptive statistics, linear regression, sample size, and hypothesis testing so that, through the pedagogical strategy of project-based learning (ABP), solve the problem.

Data collection and development

This was the development phase of the project. In the first place, the students searched for information in the library, magazines and the internet to deepen their chosen topic. Later they designed the project, following the previously explained script. Then he went on to justify the issue and analyze the needs; Afterwards, we went on to describe the population, the objective of the intervention, the contents that were worked on in the different activities, the work methodology, the scheduling, and finally the evaluation. Likewise, each group organized the tasks according to their components and objectives, for which the conditions that had to be met in the proposed solution were established: statistical methods and techniques studied in class were used to collect data. The student applied the revised knowledge in class.

Organize, analyze and interpret the data

At this stage, the students developed a report of their solution proposal applying the acquired knowledge; To do this, they used methods and techniques of organization and interpretation of results.

Solve the problem and evaluate

The students presented their project to the group. At the end of this activity, an analysis was carried out that allowed them to reflect on the lessons learned. In this section, the final written report of the project followed the following structure: title, authors, summary, introduction, objectives, materials, methods, results, discussion and conclusions, as well as references, tables, graphs and figures.

Results

Attitude perception diagnosis according to Auzmendi factors

The population studied consisted of 76 students (two groups), however only 56 students answered the survey in the first application and 42 in the second application phase of the Auzmendi survey, at the Higher School of Environmental Sciences of the UAGro. The research focused on knowing the perception of the participants about the usefulness, anxiety,

confidence, liking and motivation of the students towards statistics before and after having developed with them a pedagogical strategy based on project-based learning (PBL).

Utility factor

This factor was focused on measuring the productivity or benefits that statistics can offer students for their development as professionals (statements 1, 6, 11, 16, 20 and 21). In this sense, it can be said that regarding item 1 (I consider statistics as a very necessary subject in the career), before applying the pedagogical strategy 57.1% (32) and 28.6% (16) of the students had a positive perception (totally agree and agree) towards statistics, while after applying the pedagogical strategy the percentages decreased to 64.3% (27) and 11.9% (5) (figure 1). This decrease could be explained, because the students think that it is not a necessary and important subject for the career, others, had not taken any statistics course and this makes it difficult for them. In item 6 (I want to get to have a deeper knowledge of statistics) knowledge and usefulness towards statistics as an instrument for other areas of knowledge were evaluated. In this regard, before applying the course 58.92% (33) and 26.78% (15) of the students fully agreed and agreed with the statement raised, while after developing the course the percentages were located at 40.47% (17) and 28.57% (12), respectively. It shows the student thinks that statistics are not useful for their training, this is also verified in the implementation of the pedagogical strategy section. Item 11 (Knowing how to use statistics would increase my work possibilities) focused on the positive sense of the attitude towards statistics. Before taking the course, 39.28% (22) and 32.14% (18) of the students fully agreed and agreed with statement 11, while after the applied course the percentages were 54.76% (23) and 16.66% (7), respectively. Item 16 (For the professional development of our career, I consider that there are other subjects more important than statistics) focused on the need to use this learning unit in the educational training stage. The result shows that before the course only 10.7% (6) and 35.7% (20) of the students fully agreed and agreed with the statement, while after the course 16.66% (7) and 11.90% (5) gave their opinion like that. In item 20 (It gives me great satisfaction to solve statistical problems) before the course 21.42% (12) and 28.57% (16) of the students fully agreed and agreed with the item, while after the course 30.95% (13) and 23.80% (10) thought that way. In question 21 (For the professional development of my career, one of the most important subjects to be studied is statistics), before the course 10.7% (6) and 35.7% (20) of the students fully agreed

and agreed. according to the item, while after the course 14.28% (6) and 33.33% (14) gave their opinion in this way (figure 1).

Figura 1. Frecuencias de respuestas de los ítems 1, 6, 11, 16, 20 y 21
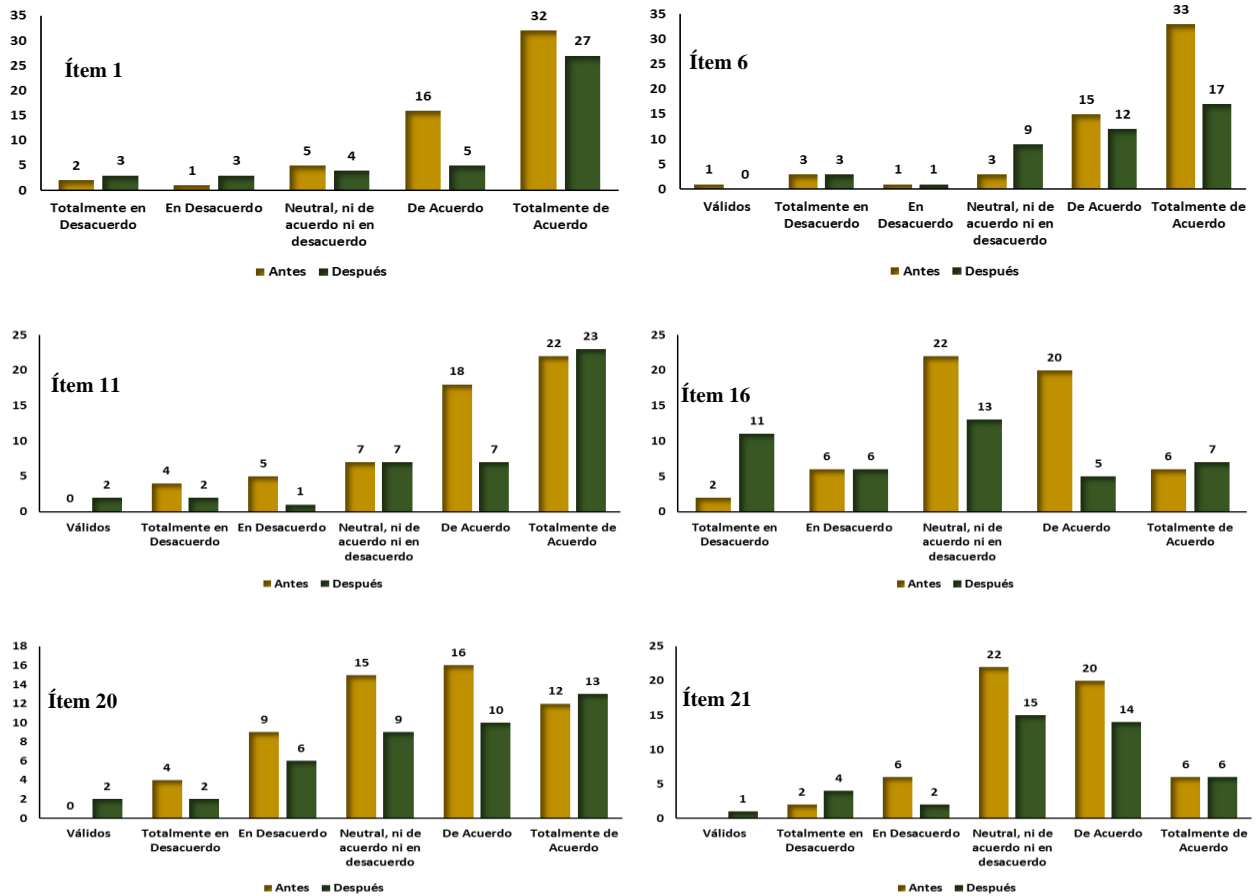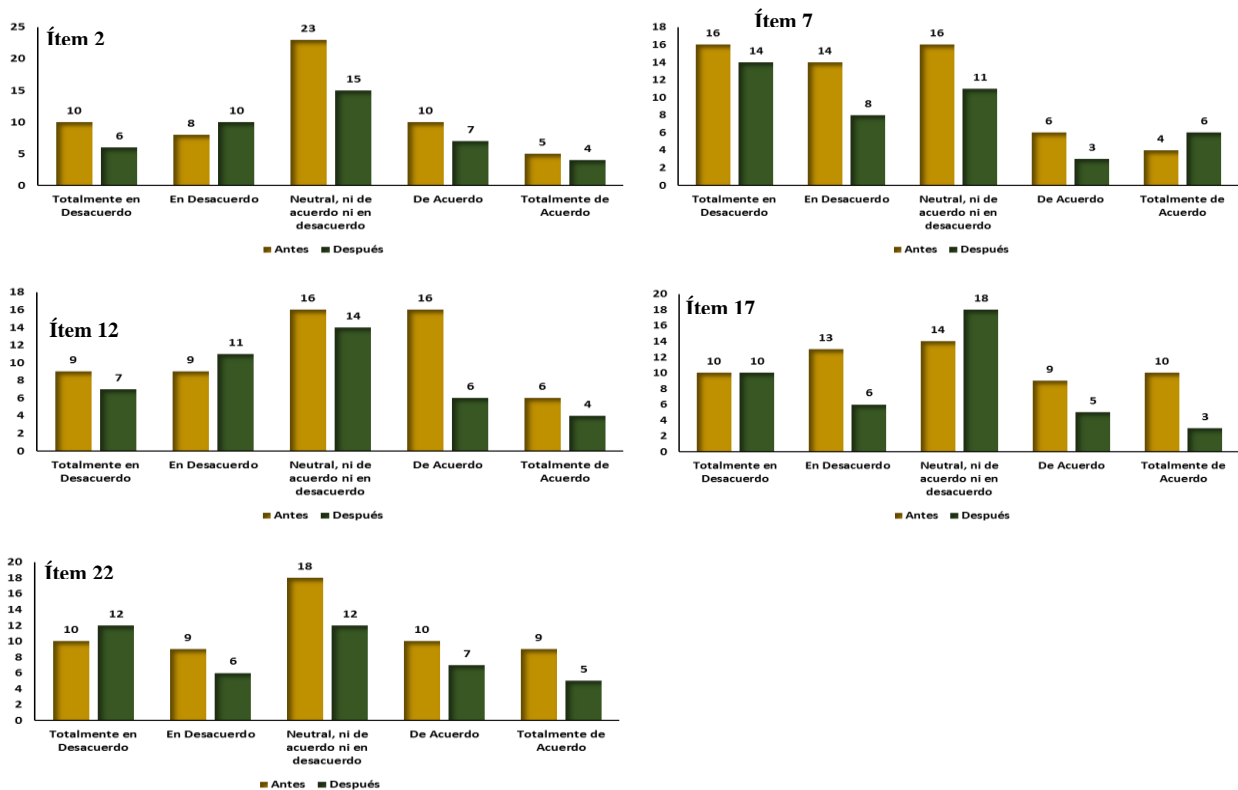

Fuente: Elaboración propia

Anxiety factor

This factor refers to the fear that the student manifests before the Statistics learning unit, which was made up of items 2, 7, 12, 17 and 22. In item 2 (I am pretty bad at the Statistics course), he refers to the student's behavior in class work. In this case, the question was phrased in reverse. Before the course, 8.92% (5) and 17.85% (10) of the students fully agreed and agreed with the item, while after the course 9.52% (4) and 16.66% (7) expressed their opinion that way. In item 7 (Statistics is one of the subjects that I fear the most) before the course 7.14% (4) and 10.7% (6) of the students fully agreed and agreed with what was stated in the item, while after of the course 14.28% (6) and 7.14% (3) thought that way.

Question 12 (When faced with a statistical problem I feel unable to think clearly) focused on fear, fear, and the social component of this learning unit through a negative statement. The results show that before the course 16.07% (9) and 16.07% (9) of the students disagree and totally disagree with what is indicated in item 12, while after the course 26.19% (11) and 16.66% (7) thought so. Regarding item 17 (Working with statistics makes me feel very nervous), before the course 23.21% (13) and 17.85% (10) of the students disagree and totally disagree with what was indicated, while that after the course the percentages stood at 14.28 (6) and 23.80% (10), respectively. In question 22 (The statistic makes me feel uncomfortable and nervous), before the course 16.07% (9) and 17.85% (10) of the students disagree and totally disagree with what was indicated, while after Of the course, the percentages were 14.28% (6) and 28.57% (12), respectively (figure 2).

**Figura 2**. Frecuencias de respuestas en los ítems 2, 7, 12, 17 y 22

Fuente: Elaboración propia

Trust factor

This factor refers to the student's safety around the contents of the statistics, and was constituted by items 3, 8, 13, 18 and 23. In question 3 (Studying or working with statistics does not scare me at all), the results indicate that before developing the course 30.35% (17) and 30.35% (17) of the students fully agreed and agreed with what was stated in the item, while after the course the percentages decreased to 11.90% (5) and 14.28% (6), respectively. In item 8 (I have confidence in myself when I face a statistical problem), before the course 23.21% (13) and 37.5% (21) of the students fully agreed and agreed with what was stated, while after the course the percentages decreased again to 28.57% (12) and 19.04% (8), respectively. In question 13 (I am calm and calm when I face a statistical problem), before the course 19.64% (11) and 23.21% (13) of the students totally agreed and agreed with that idea, while after the course the percentages were 16.66% (7) and 19.04% (8), respectively. Regarding item 18 (I don't get upset when I have to work on statistical problems), before the course developed 14.28% (8) and 32.14% (18) of the students fully agreed and agreed with the approach, while after the course 16.66% (7) and 23.80% (10) gave their opinion in this way, respectively. Finally, in question 23 (If I proposed it to myself, I believe that I would master statistics well) it is evidenced that 58.92% (33) and 23.21% (13) of the students fully agree and agree with the approach, while after the course, 50.00% (21) and 19.04% (8) expressed their opinion in this way, respectively (figure 3).

**Figura 3.** Frecuencias de respuestas en los ítems 3, 8, 13, 18 y 23
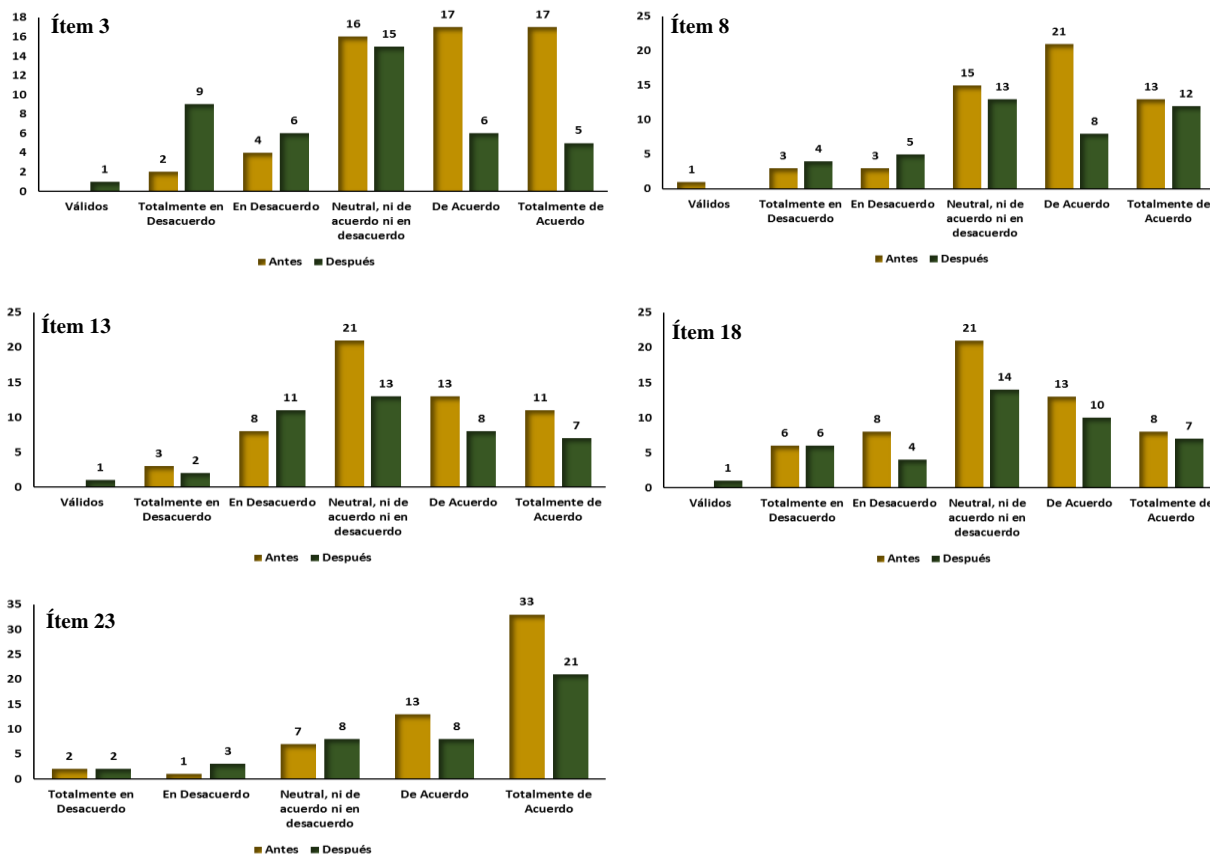
Fuente: Elaboración propia

Pleasure factor

This factor was made up of items 4, 9, 14, 19 and 24. In question 4 (Using statistics is fun for me) a neutral position prevailed before and after applying the course —41.07% (23) and 28.57% (12), respectively—. The cause of this could be that the students had not taken any statistics course at the upper secondary level. Something similar happened with question 9 (I have fun talking to others about statistics), because before and after developing the course a neutral position prevailed in the students: 33.92% (19) and 38.09% (16), respectively. On the other hand, in question 14 (Statistics is pleasant and stimulating for me) the students did favor a position, because before the course 16.07% (9) and 33.92% (19) of them fully agreed and agreed with the approach, while after the course 16.66% (7) and 28.57% (12) expressed their opinion in this way, respectively. In question 19 (I would like to have an occupation in which I had to use statistics), a neutral position also stood out, since

before the course 48.2% (27) of the students spoke that way, while after the course that percentage stood at 30.95% (13). Finally, in question 24 (If I had the opportunity, I would enroll in more statistics courses than are necessary), before the course 23.21% (13) and 44.64% (25) of the students fully agreed and agreed with the approach, while after the course 26.19% (11) and 30.95% (13) expressed their opinion in this way, respectively (figure 4).

Figura 4. Frecuencias de respuestas en los ítems 4, 9, 14, 19 y 24
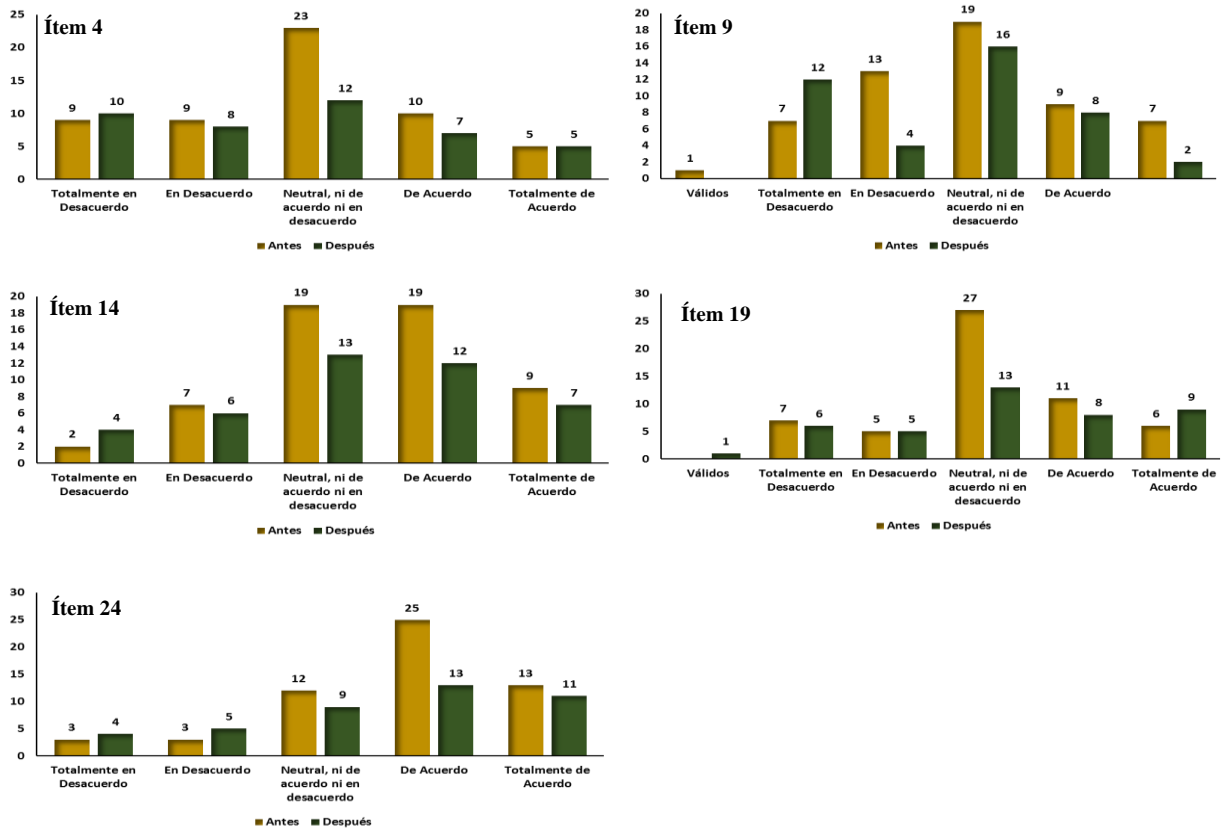
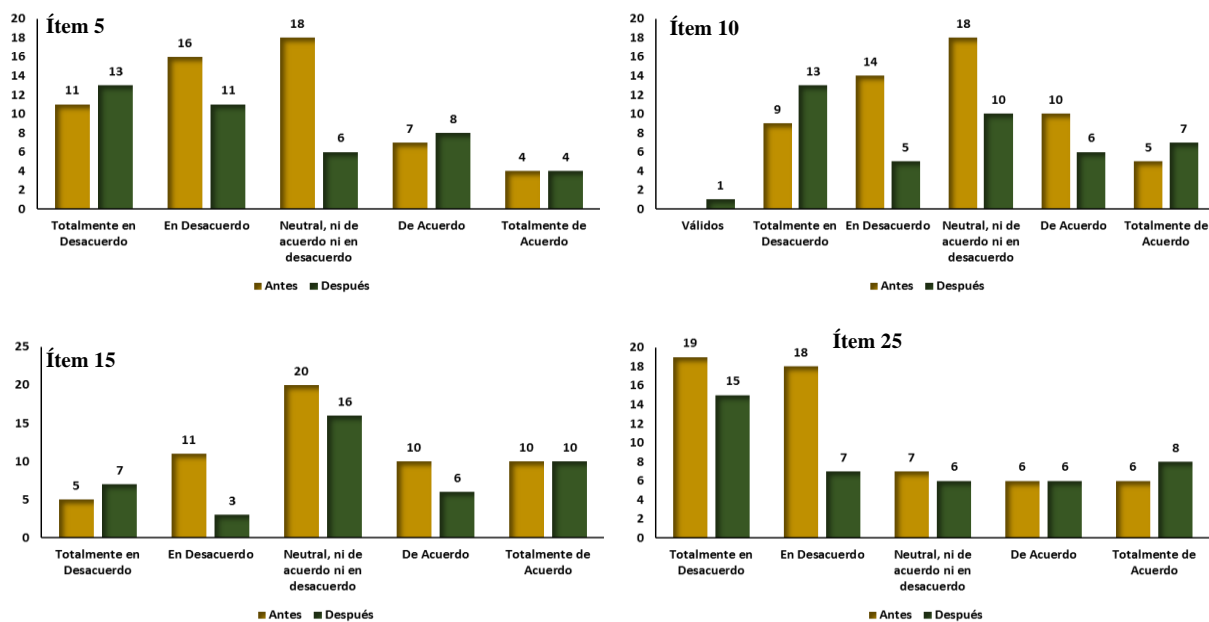Fuente: Elaboración propia

Motivation factor

The motivation factor was made up of items 5, 10, 15 and 25, which are described below. Regarding item 5 (Statistics are too theoretical to be of practical use for the average professional), before the course 28.57% (16) and 19.64% (11) of the students disagreed and totally disagreed with that affirmation, while after the course the percentages were located at 26.19% (11) and 30.95% (13), respectively. In statement 10 (Statistics can be useful for those who are dedicated to research, but not for the average professional), before the course 25% (14) and 16.07% (9) of the students thought that they disagreed and totally disagree with that

idea, while after the course the percentages were 11.90% (5) and 30.95% (13), respectively. Regarding statement 15 (I hope I have to use statistics little in my professional life), before the course most of the students assumed a neutral position —35.7% (20) -, while after the course this percentage stood at 38.09% (16). Finally, in question 25 (The subject taught in statistics classes is very uninteresting), before the course 32.14% (18) and 33.92% (19) of the students disagreed and totally disagreed with the statement , while after the course the percentages were 16.66% (7) and 35.71% (15), respectively (figure 5).

Figura 5. Frecuencias de respuestas en los ítems 5, 10, 15 y 25

Fuente: Elaboración propia

Implementation of the pedagogical strategy

Table 2 shows the general results in terms of the means of the scores obtained with the application of the survey of attitudes towards statistics (made up of the 25 items mentioned). However, before showing these results, it is worth noting that the items written in a negative way (for example, number 2: The subject of Statistics is quite bad for me) were scored inversely to calculate their mean. In this way, a high mean will always indicate a positive attitude towards statistics. Now, the best-valued average values before taking the statistics course were the following: I consider statistics as a very necessary subject in the career, if I

proposed it to myself, I believe that I would master Statistics well (items 1 and 23) and I want to have a deeper knowledge of statistics (item 6) (of utility and trust factors). On the other hand, the worst valued were the aspects related to statistics, it is one of the subjects that I fear the most and the subject taught in statistics classes is very uninteresting (items 7 and 25) (of the anxiety and confidence factors) (table 2). On the other hand, the best-valued mean values after taking the statistics course were the following: I consider statistics to be a very necessary subject in the career and if I proposed it, I think I would have mastered statistics well (items 1 and 23) (of utility and confidence factors). The worst correspond to aspects related to statistics, it is too theoretical to be of practical use for the professional environment and statistics is one of the subjects that I fear the most (items 5 and 7) (of the motivation and anxiety factors) (table 2). Continuing with this analysis of negative and positive attitudes, Table 2 shows that before the course in questions 2, 4, 5. 7, 9, 10, 16, 17, 22, 25 and after the course in questions 2, 3, 4, 5. 7, 9, 10, 12, 16, 17, 22 and 25 show negative attitudes, since they present values lower than 3. However, it is also worth noting that in the referred items of some students manifested in a positive way, which is demonstrated in the following arguments, these arguments were collected with the semi-structured survey with the 9 open questions: statistics as a very necessary subject in the career, "it is made easier for me because it is interesting", "taking the sequence is simple, although sometimes I do not understand the procedure and I get lost "," well, in particular I try to understand and understand the statistics "," yes it is facilitated to me to be able to solve some graphs or data that we want to obtain ", "It is not complicated, but it is not very easy either."

Studying or working with statistics does not scare me at all: "it seems easy to me because everything has been seen and I have understood", "for the graphs it is easy for me to do them, the problems are a bit complicated", "it is easy because I find it interesting when relating it to all the data "," it is easier for me, since they are simple procedures "," it seems to me a simple matter, sometimes a bit tedious ". I want to get to have a deeper knowledge of statistics: "read a little more, be more responsible and pay more attention in class", "study, not be left with doubts and put what I have learned into practice", "document myself more, get involved in the various school activities and fulfill tasks and projects "," pay more attention to the classes, be more responsible and study ". Knowing how to use statistics would increase my job possibilities: "at least for me it will increase my chances of getting a job", "if it will be useful for me when I already have a job according to my

career", "it is useful to know statistics for my profession , since it is used daily in any job "," knowing statistics is useful in my profession ". If I set my mind to it, I think I would come to master statistics well: "it is a goal of life to have statistical knowledge and for this it is necessary to discipline myself, apply myself and have more responsibility", "be more responsible every day and put more interest in my learning towards statistics "," study, not be left with doubts and put into practice what I have learned ".

As can be seen in these excerpts, the previous explanations are linked to the utility and trust factors, since in general they refer to the usefulness of this knowledge for their professional future; This was done based on the analysis of the results of the quantitative questionnaire, Auzmendi survey, and qualitative ones based on the semi-structured survey of 9 open questions. On the other hand, from the negative arguments we highlight the following: I am quite bad at the Statistics subject: "yes, I had never taken the course until now, and yes I am liking it because you learn to graph very well", "it is the first Once I take it, I do like to learn this subject, that I take it to high school ". The subject taught in statistics classes is very uninteresting: "the ways to do it are uninteresting, I find it a bit complicated, but useful, I like it a bit and possibly necessary", "in high school I took the course of statistics, I found it very interesting, since the teacher explained us very well, I liked it because it was very interesting ". As for Statistics is too theoretical to be of practical use for the average professional and Statistics can be useful for those who dedicate themselves to research, but not for the average professional, the following opinions are offered: "at least for I will be a bit useful, because for example in any job they can put us to graph and I think for any job it will be used sometime "," it is not theoretical and it will be useful for me when I already have a career, when I already have a job according to my career "," I think that if it is in the study plan it is for something, I think it is very good in the career ". In summary, it can be observed that these testimonies are linked to the cognitive component (usefulness, anxiety, liking and motivation). Likewise, it can be seen that some students have not taken a statistics course during their training at the upper secondary level, while those who have taken this type of subjects seem to have forgotten that content because at the time it seemed little useful or they were not adequately motivated about the benefits of that knowledge for everyday life. Therefore, it can be said that it is necessary to create strategies that motivate more and show the usefulness of the subject.

Tabla 2. Medias de las puntuaciones obtenidas con la aplicación de la encuesta de actitudes hacia la estadística (antes y después de tomar el curso)

	Antes Media	Después Media
1. Considero a la estadística como una materia muy necesaria en la carrera	4.34	4.19
2. La asignatura de Estadística se me da bastante mal	2.86	2.83
3. El estudiar o trabajar con la estadística no me asusta en absoluto	3.77	2.74
4. El utilizar la estadística es una diversión para mí	2.88	2.74
5. La estadística es demasiado teórica como para ser de utilidad práctica para el profesional medio	2.59	2.5
6. Quiero llegar a tener un conocimiento más profundo de la estadística	4.27	3.93
7. La estadística es una de las asignaturas que más temo	2.43	2.5
8. Tengo confianza en mí mismo/a cuando me enfrento a un problema de estadística	3.63	3.45
9. Me divierte el hablar con otros de estadística	2.88	2.62
10. La estadística puede ser útil para el que se dedique a la investigación, pero no para el profesional medio	2.79	2.67
11. Saber utilizar la estadística incrementaría mis posibilidades de trabajo	3.88	4
12. Cuando me enfrento a un problema de estadística me siento incapaz de pensar con claridad	3.02	2.74
13. Estoy calmado/a y tranquilo/a cuando me enfrento a un problema de estadística	3.38	3.1
14. Estadística es agradable y estimulante para mí	3.46	3.29
15. Espero tener que utilizar poco la estadística en mi vida profesional	3.16	3.21
16. Para el desarrollo profesional de nuestra carrera considero que existen otras asignaturas más importantes que la estadística	2.88	2.79
17. Trabajar con la estadística hace que me sienta muy nervioso/a	2.93	2.64
18. No me altero cuando tengo que trabajar en problemas de estadística	3.16	3.12
19. Me gustaría tener una ocupación en la cual tuviera que utilizar la estadística	3.07	3.14
20. Me provoca una gran satisfacción el llegar a resolver problemas de estadística	3.41	3.48
21. Para el desarrollo profesional de mi carrera una de las asignaturas más importantes que ha de estudiarse es la estadística	3.39	3.31
22. La estadística hace que me sienta incómodo/a y nervioso/a	2.98	2.69
23. Si me lo propusiera creo que llegaría a dominar bien la estadística	4.32	4.02
24. Si tuviera oportunidad me inscribiría en más cursos de estadística de los que son necesarios	3.75	3.52
25. La materia que se imparte en las clases de estadística es muy poco interesante	2.32	2.64

Fuente: Elaboración propia

Cognitive aspects

The survey to measure knowledge after taking the statistics course was answered by only 51 students (two groups). Table 3 shows the results in terms of number of correct answers and percentage of correct answers in each of the questions in the survey of acquired knowledge of the Statistics learning unit of the degree in Environmental Sciences.

**Tabla 3.** Resultados de la encuesta para medir conocimiento

Pregunta	Aciertos	Porcentaje de aciertos
1) Tipo de variable estadística.	31	60.8 %
2) Pregunta sobre la mediana.	46	90.2 %
3) Pregunta sobre la media.	38	74.5 %
4) Tipo de gráfico.	48	94.1 %
5) Diagrama de cajas y bigotes.	8	15.7 %
6) Tamaño de la muestra.	39	76.5 %
7) Análisis de regresión lineal	45	88.2 %
8) Contraste de hipótesis	32	62.7 %
9) Modelo lineal simple	29	56.9 %
10) Recta de regresión	10	19.6 %

Fuente. Elaboración propia con base en Ayuga, González, Grande y Martínez (2012).

Questions 1, 2, 3, 4, 6, 7, 8 and 9 obtained a percentage of correct answers higher than 60%. These questions correspond to the blocks of descriptive statistics, sample size, regression analysis, and hypothesis testing. On the other hand, the two remaining questions (5 and 10) did not exceed 20% correct answers. Figure 6 (a) shows the responses obtained for the first five questions of the evaluation survey, corresponding to the descriptive statistics thematic block. The correct answers to each question have been marked in red. Note that most of the students answered correctly only in question 5, in which the majority opted for the mode, which shows that the box plot is not understood. Likewise, the majority response in question 1 was option a, which represents the type of discrete variable, which shows that they know the types of variables. In the case of question 2, the correct answers (part c) allow us to deduce that students dominate the calculation of the median more. The same happens in the case of the calculation of the mean (part b) and the representation of the graphs (part c), so it can be said that descriptive statistics dominate. On the other hand, Figure 6 (b) shows the answers to the questions of the thematic block sample size, hypothesis testing and linear regression (items 6 to 10). In these blocks, of the three options, the correct answer (indicated in red) was chosen in a majority in four of the five questions, except for question 10. In this question the

most chosen answer was section c) which, in The way to carry out linear regression or linear modeling is confusing or not clear about the subject of the question. From this data, it can be inferred that the students have knowledge of the blocks of sample size, hypothesis testing and linear regression.

Figura 6. Respuestas obtenidas de bloque de estadística descriptiva, bloque tamaño de muestra, contraste de hipótesis y regresión lineal
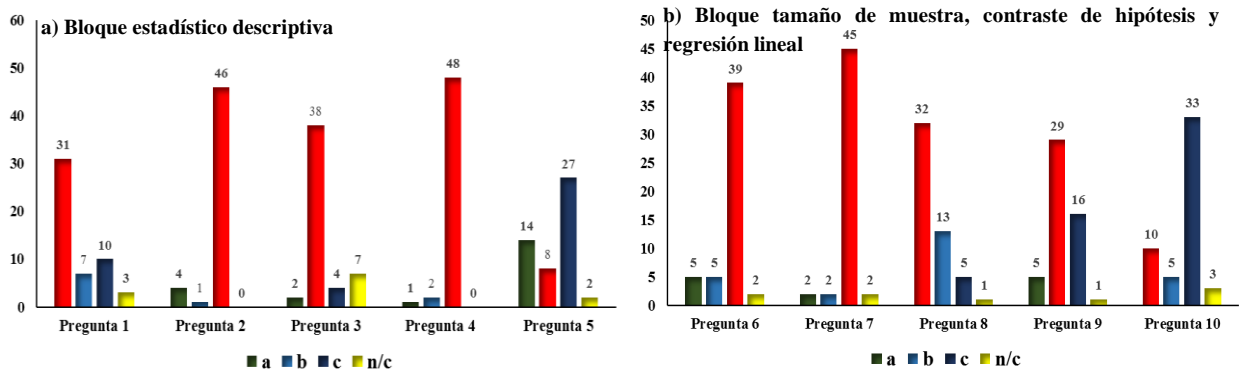
Fuente: Elaboración propia

Pedagogical strategy based on project-based learning (PBL)

At the beginning of the course, the students were asked to carry out and carry out a project, in which the theoretical concepts seen in the descriptive statistics, sample size, hypothesis contrast and linear regression classes would be applied. The result on the perception of the use of the PBL pedagogical strategy is shown in table 4. This survey was answered by only 52 students (made up of two groups). In the first question, the majority (94.2%) of the students considered that the pedagogical strategy implemented is an important support in their professional development. In the second question, half considered that it was difficult to find a project idea to develop in the statistics course. In question 3, on whether the topics and concepts seen in class were explained for the solution of the project problems, only 11.5% of the students answered negatively. According to the results of question 4, the majority (80.8%) of the students considered that the pedagogical strategy was worked on appropriately during the semester. On question 5, 86.5% of the surveyed students agreed with the way of doing the work. In this sense, the students as they progressed in the project showed an improvement, a greater ability to synthesize and analyze the results they had partially from their progress.

In question 6, the perception of the students about the assessment of the final work (oral and written presentation, as well as the total percentage of the semester evaluation that corresponds to 40%) was found. In this sense, 63.5% of the surveyed students agreed with this assessment. Regarding question 7, the majority of the surveyed students (67.3%) considered that the time for the development of the practical part of the project was sufficient; However, a number of respondents expressed themselves negatively (28.8%), arguing that the time set was not enough due to the logistical problems they had in their school activities.

In question 8, more than half of the students (69.2%) stated that teaching through the pedagogical strategy carried out satisfied their educational expectations, for which they made various comments about the importance of this type of initiative. In question 9, almost half (44.1%) of the respondents believed that the conditions and lack of equipment made the development of the project difficult. In this sense, it is worth mentioning that there were programming and logistics problems with some teams to develop practical field activities, mainly. However, it can also be said that this type of situation can be used to develop the ingenuity and imagination of students, since in daily life and work these types of problems can arise. In question 10, 76.9% of the respondents considered that the expectations regarding the management carried out by the teacher in the development of the project during the statistics course were met.

Tabla 4. Resultados de la encuesta sobre la implementación de la estrategia pedagógica en la Escuela Superior de Ciencias Ambientales

Pregunta	Sí	%	No	%	N/C	%
1. ¿Cree usted que trabajar con proyecto en clase es importante para su formación profesional?	49	94.2%	3	5.8%		0.00%
2. ¿Le fue difícil encontrar una idea de proyecto apropiado para desarrollar en el curso de estadística?	26	50.0%	26	50.0%		0.00%
3. ¿Se explicaron y aplicaron los temas y conceptos vistos en clase para la solución de los problemas del proyecto de clase?	46	88.5%	6	11.5%		0.00%
4. ¿Cree usted que la forma de realizar el proyecto durante el semestre fue la adecuada?	42	80.8%	10	19.2%		0.00%
5. ¿Está conforme con la forma de realizar los trabajos y (entrega) del proyecto durante el semestre?	45	86.5%	7	13.5%		0.00%
6. ¿Considera que la valoración final del proyecto corresponda al 40 % de la calificación final de la unidad de aprendizaje?	33	63.5%	19	36.5%		0.00%
7. ¿El tiempo estipulado para el desarrollo del proyecto es suficiente?	35	67.3%	15	28.8%	2	3.85%
8. ¿Este tipo de metodologías para el aprendizaje satisfacen sus expectativas como estudiante si se compara con otros métodos tradicionales de enseñanza?	36	69.2%	15	28.8%	1	1.92%
9. ¿Considera que los materiales, equipos de laboratorios y demás recursos disponibles actualmente son los adecuados para el desarrollo de la parte experimental del proyecto?	27	51.9%	23	44.2%	2	3.85%
10. ¿Usted considera que la orientación para el desarrollo del trabajo por parte del docente cumplió con sus expectativas?	40	76.9%	11	21.1%	1	1.92%

Nota: Las preguntas de la tabla 4 fueron tomadas y adaptadas de Rodríguez y Cortés (2010)

Fuente: Elaboración propia

Discussion

This research focused, in the first place, on analyzing the attitudes towards learning and elementary knowledge of statistics of students of the degree in Environmental Sciences of the Higher School of Environmental Sciences of the Autonomous University of Guerrero. Then, based on the results obtained, a pertinent pedagogical strategy was applied to guide the teaching process and reduce the lag in the referred subject. In this sense, it can be said that the process of the project-based learning strategy becomes a key piece to understand the attitude of students towards statistics and, above all, to try to modify the way in which they

construct their learning . Specifically, and based on the results obtained, a pedagogical strategy of this nature could serve to significantly change the attitude of students and improve academic results in learning units with statistical content. The results obtained, therefore, lead us to think that the attitude towards statistics is based on a taste for the discipline. In this sense, the students recognize the importance and usefulness of this disciplinary area, which is evidenced in the findings obtained in item 1 (I consider statistics as a very necessary subject in the career), item 6 (I want to have a deeper knowledge of statistics), item 11 (Knowing how to use statistics would increase my job possibilities), item 16 (For the professional development of our career, I consider that there are other subjects more important than statistics); Item 20 (It gives me great satisfaction to get to solve statistics problems) and item 21 (For the professional development of my career, one of the most important subjects to be studied is statistics). These results coincide with those found by Salinas and Mayén (2016), Rojas, Escalera, Moreno and García (2017) and Sánchez (2019). Regarding the anxiety factor (made up of items 2, 7, 12, 17 and 22), after the course: it can be indicated that 38.1% of the students disagree with item 2 (The Statistics course is quite wrong); Likewise, 52.4% do not agree with item 7 (Statistics is one of the subjects that I fear the most). In item 12 (When faced with a statistical problem, I feel unable to think clearly), the majority (76.2%) of the sample divided their response neutrally and in disagreement. In item 17 (Working with statistics makes me feel very nervous), the majority also (81%) divided their answer. These results coincide with those found by García *et al.* (2016), Rojas *et al.* (2017) and Sánchez (2019).

In the confidence factor (questions 3, 8, 13, 18 and 23), the majority of the students having completed the learning unit responded neutrally to question 3 and 8 (Studying or working with statistics does not scare me not at all and I am confident in myself when faced with a statistical problem) (35.7% and 31%, respectively). For question 13 (I am calm and calm when faced with a statistical problem), 33.3% of the students stated that they felt calm when working with a statistical problem. Likewise, for question 18 (I don't get upset when I have to work on statistical problems) most of the students agree with what has been stated. These findings coincide with Sánchez's (2019) research. Regarding the pleasure factor (items 4, 9, 14, 19 and 24), it can be said that in item 4 (Using statistics is fun for me) an unfavorable attitude towards statistics was registered. In question 9 (It amuses me talking to other statistics), most of the students answered neutrally or disagreed with what was suggested. However, in question 14 (Statistics is pleasant and stimulating for me) it was evidenced that

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students have an unfavorable attitude towards statistics. Similarly, in question 19 (I would like to have an occupation in which I had to use statistics) the students stated that they disagreed or were neutral in relation to what was indicated. In question 24 (If I had the opportunity, I would enroll in more statistics courses than are necessary) the students were neutral to the statement. These are similar to those of Sánchez (2019). In the motivation factor (made up of items 5, 10, 15, 20 and 25), it was found that the majority (57.1%) of the students disagree with statement 5 (The statistic is too theoretical to be useful practice for the average professional). However, they consider that it is useful for the professional who is not dedicated to research. These results are similarly similar to those found by Sánchez (2019). In general, the findings indicate that the majority of the 56 students in the sample showed a positive attitude towards statistics, results similar to those found by Bautista et al. (2016), who worked with students from different careers from the University of Sonora.

Likewise, regarding the results of the implementation of the project-based learning strategy, it can be affirmed that the great acceptance, the positive attitude and the sense of utility found towards statistics by the students coincides with that reported by Astorga , Flores, Ibarra, Mariscal and Vizcarra (2017), Inzunza (2017), Flores and Juárez (2017) and Toledo, Arellano, Aguilar and Molina (2018) at the undergraduate level from different universities in Mexico. Finally, we can say that this research provides evidence to improve the teaching and learning process, as well as to motivate the student around the advantages that statistics offer not only for daily life, but also for good professional performance.

Conclusions

From the questions in the Auzmendi survey, it can be concluded that the students perceived the usefulness of statistics, since 85.7% of them consider that this discipline is a very necessary one in the environmental sciences career, so they want to have a deeper knowledge of statistics. Likewise, 71.5% consider that knowing how to use statistics will increase their work possibilities, and half of the participants find it highly satisfied when they solve statistical problems. In this sense, 47.6% of the students demonstrated that they were aware of the importance of statistics in their training, although it is also worth mentioning that another group of students considers that "for the professional development of our career I consider that there are other subjects more important than statistics "—this item was the only one that obtained a mean lower than 3 (2.88) -. Regarding the anxiety

component, the students have shown a negative perception towards statistics due to the capacity that it may have in distorting the results of a study. In fact, in the item The subject of Statistics I am quite bad, 26.8% of those surveyed agree with the statement. In the item Statistics is one of the subjects that I fear the most, more than half expressed themselves in a neutral way. On When I am faced with a statistical problem I feel unable to think clearly, a third of respondents (39.3%) agree with the statement, while on Working with statistics it makes me feel very nervous. statistics makes me feel uncomfortable and nervous, these two items got 39.55% in terms of disagreement with the statement. Some of the justifications of the students in this regard were the following: "I had never taken the course until now", "it is the first time that I take it, that I take it in high school" and "it is the first time that I have taken this subject." Regarding trust, it can be concluded that Environmental Sciences students have positive attitudes towards statistics as a form of reasoning, as evidenced by items 1, 6, 11, 16 and 21, which reached means higher than 3.

It can also be said that students like statistics, and would even like to have an occupation in which they had to use that knowledge. Even so, it is worth noting that it is not fun for a group of students to talk to others about statistics outside of school. Finally, it can be pointed out that students perceive that Statistics is too theoretical to be of practical use in the professional sphere. In summary, it can be concluded that the perception of having to use statistics little in my professional life is slightly high. Therefore, there is a need to work on the attitude towards statistics of these students through an appropriate learning strategy that serves to motivate and support educational performance. Regarding the questions formulated to determine the level of theoretical knowledge acquired after developing the statistics course, it can be noted that the percentages and frequencies of "correct answers" are satisfactory, since in questions 1, 2, 3, 4, 6, 7, 8 and 9 were achieved hits higher than 60%. In general, the students' perception of this type of pedagogical learning strategy is very good, although the other classroom factors must be considered (fatigue, laziness, etc.) to achieve a better execution of the activities.

Future lines of research

Based on the evidence obtained, various questions have arisen that can be considered in future studies to provide a better understanding of the problem that was addressed. It is necessary to develop studies that consider in greater depth each of the factors that influence the negative attitude towards learning statistics in students. The evidence derived from the analysis of the positive and negative attitudes shown by the students may have some relationship with the attitudes that the students have towards the teacher. In the same way, it is necessary to carry out studies on factors that influence student learning, which seem to have an important influence on the locomotion of knowledge towards statistics.

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