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PROJECT-BASED LEARNING IN SCIENCE DISSEMINATION WITH UNIVERSITY STUDENTS OF PLANT BIOTECHNOLOGY

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KEYWORDS

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Project-based learning
Transgenic plants
Scientific vocations
Dissemination talks

ABSTRACT

At present, the European population sees more risks than benefits in the use of transgenic plants in food. Through the development of a learning strategy based on science dissemination projects (articles and talks) by university students, an increase in autonomous knowledge and vocations in science popularisation has been identified. On the other hand, the development of outreach talks for pre-university students has increased the knowledge of outreach and plant biotechnology, promoting the future choice of higher studies in biotechnology.

PALABRAS CLAVE

Aprendizaje autónomo
Aprendizaje basado en proyectos
Plantas transgénicas
Vocaciones científicas
Charlas divulgativas

RESUMEN

En la actualidad, la población europea aprecia más riesgos que beneficios en el uso de plantas transgénicas en alimentación. Mediante el desarrollo de una estrategia de aprendizaje basado en proyectos de divulgación científica (artículos y charlas) por estudiantes universitarios se ha identificado un aumento del conocimiento autónomo y de vocaciones sobre divulgación científica. Por otro lado, el desarrollo de las charlas de divulgación para estudiantes preuniversitarios ha aumentado el conocimiento sobre divulgación y biotecnología vegetal, promoviendo la elección futura de estudios superiores en biotecnología.

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1. Introduction

Plant biotechnology, and transgenic plants in particular, do not enjoy a positive public perception, especially in the European Union. Despite the fact that their benefit to society and lack of risk have been demonstrated over years of research, the public has no access to real scientific information and continues to have misconceptions about these new developments.

Scientific dissemination represents a good strategy to bring complex scientific knowledge closer to society, in a clear and accessible way. Its use in the field of plant biotechnology is absolutely necessary, not only for farmers, but for society as a whole.

In this work we have carried out a project-based learning of scientific dissemination within the university subject of Plant Biotechnology, in order to promote autonomous learning of university students and their vocation as science communicators. In addition, the results of these science popularization projects were used in pre-university students, in order to increase their knowledge regarding science popularization and plant biotechnology, as well as to promote the choice of higher studies related to plant biotechnology.

2. Literature review

2.1. Project-based learning (PBL)

Project-based learning (PBL) is a constructivist teaching-learning method based on students' development of complex real-world tasks, resulting in a product or public presentation that enables them to acquire important knowledge and application skills in their lives (Chen & Yang, 2019). APB is based on students' "need to know", leaving aside teachers' "should know" (Chen & Yang, 2019). The whole system of PBL is based on students developing a project through constructive, medium- to long-term research, allowing for group work and discussion (collaborative learning) and significant development of oral and written communication skills (Chen & Yang, 2019).

Lecture-based education is not able to develop a correct and fruitful learning process in students, leading to a total lack of motivation and the impossibility of developing optimal problem-solving skills (Chiang & Lee, 2016). On the contrary, PBL manages to involve students in the search for solutions to real and global problems (Fidalgo-Blanco et al., 2017), improving their critical thinking skills (Eliyasni et al., 2019), creative thinking (Hanif et al., 2019; Wijayati et al., 2019), increasing academic performance (Chen & Yang, 2019) and motivation to learn about the content of the subject (Almulla, 2020). In addition, it increases teachers' vocational motivation, developing important skills for their professional development, as well as developing important skills in students that they can use in everyday problem solving, improving the benefit of education on society in general (Miller et al., 2021).

With regard to higher education, PBL can be developed at all stages of education, from primary school to postgraduate level (Kokotsaki et al., 2016). In higher education, it has been shown that the implementation of PLA in universities stimulates students' creativity and promotes the acquisition of a wide range of competences (Lasauskiene & Rauduvaite, 2015; Ngereja et al., 2020), being fully connected to the competence-based learning promoted by the Bologna Declaration for the European Higher Education Area (Bezanilla et al., 2019).

2.2. Science dissemination and university education

Science dissemination is defined as the communication of science to society at large, including people without basic scientific knowledge, through communication strategies and active interactions, enabling the dissemination of science (Beck et al., 2019; Galvão et al., 2021). Traditionally, science dissemination has been carried out through the written press, specific books, television and radio. However, nowadays, social networks represent the main channel for the transmission of information, allowing the development and dissemination of strategies such as science dissemination articles, recorded lectures, animated videos and podcasts. In addition, the organization of science talks and workshops in popular environments, such as bars or squares, is bringing scientific knowledge closer to citizens in an enjoyable way (Tan & Perucho, 2018; Yuan et al., 2021).

According to the United Nations 2030 agenda, the development of quality university education must be linked to the development of correct communication and knowledge dissemination skills (Arroyo-González et al., 2020). In this sense, several studies have determined how the development by university students of different scientific dissemination strategies favors autonomous learning and the development of important oral and written communication skills (Balgopal & Wallace, 2013; Zorzo et al., 2021).

2.3. Plant biotechnology social perception

Biotechnology is defined as the use of organisms or their derivatives for the development or modification of processes or products (Johnson-Green, 2018). Plant biotechnology includes transgenic crops or plants, which are plants that have been genetically engineered with a gene from another organism that cannot reproduce naturally, for example, a bacterium or an animal (Johnson-Green, 2018).

Public perception analyses of biotechnology have historically focused on GM foods. However, it has been found that society at large is massively supportive of developments in non-agricultural biotechnology, such as the development of new drugs and vaccines (Azodi & Dietz, 2019). Despite the fact that GM crops help reduce greenhouse gas emissions, are more resistant to diseases and pests, produce more and provide more nutrients to humans and animals, society in general, and especially in the European Union, has a low acceptance level (Woźniak et al., 2021).

In particular, society perceives more risks than benefits in the development and uses of GM crops, both for the environment and for health (Ghasemi et al., 2020). In this sense, there is an irrational fear that is fully instilled in all citizens, because even if consumers are fully aware of the benefits of GM foods and the absence of dangers, they will choose non-GM foods to a greater extent (Boccia & Punzo, 2021).

2.4. Relationships between PBL, science dissemination and plant biotechnology

The current public debate on the use of GM crops accentuates the urgent need to create effective channels of communication between scientists and society at large (Brossard, 2019). Science dissemination has been proposed as an effective pedagogical tool in the classroom to bring complex scientific knowledge closer to both the students who carry out the dissemination activities and the rest of the citizens who receive the results of their dissemination work (Debije et al., 2019; Sguerso et al., 2019). Similarly, the implementation of PBL methodologies in the classroom has been able to improve learning and skills development in subjects closely related to plant biotechnology, such as biology (Salybekova et al., 2021), botany (Jumaheni et al., 2021), biochemistry (Li et al., 2020) or bioengineering (Young et al., 2021), as well as in specific subjects such as plant tissue culture (Martín et al., 2021).

3. Objectives

- - To determine whether the PBL by science dissemination in plant biotechnology carried out by university students favors autonomous learning in science dissemination and promotes their vocation as science communicators.
- - To check whether any of the results of this PBL increases knowledge about plant biotechnology and science communication in pre-university students, as well as promoting the future choice of studies related to biotechnology.

4. Methodology

4.1. Sample

The study was carried out with two different groups of students: university students and pre-university students. The group of university students included all the students enrolled in the subject Plant Biotechnology in the third year of the Degree in Biotechnology at the Public University of Navarra during the 2021-2022 academic year: 38 people (13 boys and 25 girls, aged between 20 and 22 years). On the other hand, the group of pre-university students was made up of students in the first and second years of the baccalaureate in science: 48 people (12 boys and 36 girls, aged between 16 and 19 years). Non-probabilistic convenience sampling was used.

4.2. Method, instruments and procedure

The research methodology used to analyze the objectives fulfilment in both samples was quantitative, using a pre-experimental pretest-posttest single-group design. In both samples, two surveys were carried out, before and after the science outreach experience, with multiple-choice questions. For the group of university students, the surveys included questions related to knowledge about science dissemination and vocation as science disseminators. However, for the group of pre-university students, the surveys included questions about basic knowledge of science dissemination and plant biotechnology, as well as future studies they plan to undertake.

In the group of university students, the development of the science dissemination project (PBA) was based on the elaboration, in pairs, of a short science dissemination article (2-3 pages) (articles compiled in a science dissemination book; Figure 1) and a short science dissemination talk (10 minutes) on applications of transgenic plants, choosing the topic freely. The surveys were carried out before starting the projects and just after finishing them. The science talks were the chosen form of interaction between university and pre-university students. The pre-university students completed the surveys before and after receiving the science talks given by the university students.

Figure 1. Book published with short popular science articles written by university students.

Source: Poveda Arias, 2022.

4.3. Data analysis

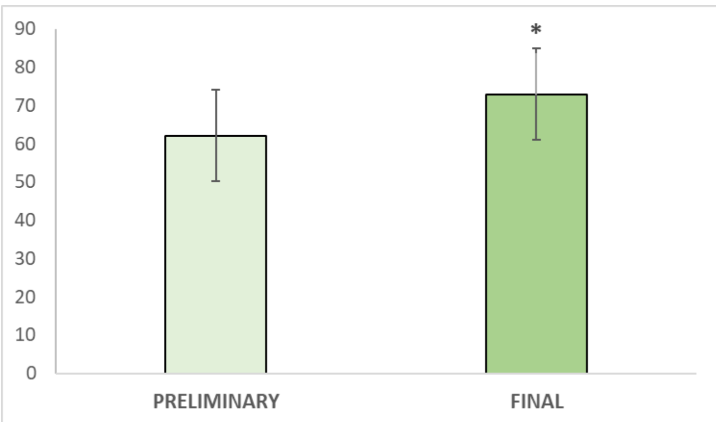
In each of the surveys, each of the questions was scored according to the answer given. The statistical analysis carried out was Student's t-test, comparing the results of both surveys with each other and indicating significant differences ($P \leq 0.05$) with an asterisk.

5. Results

5.1. University students

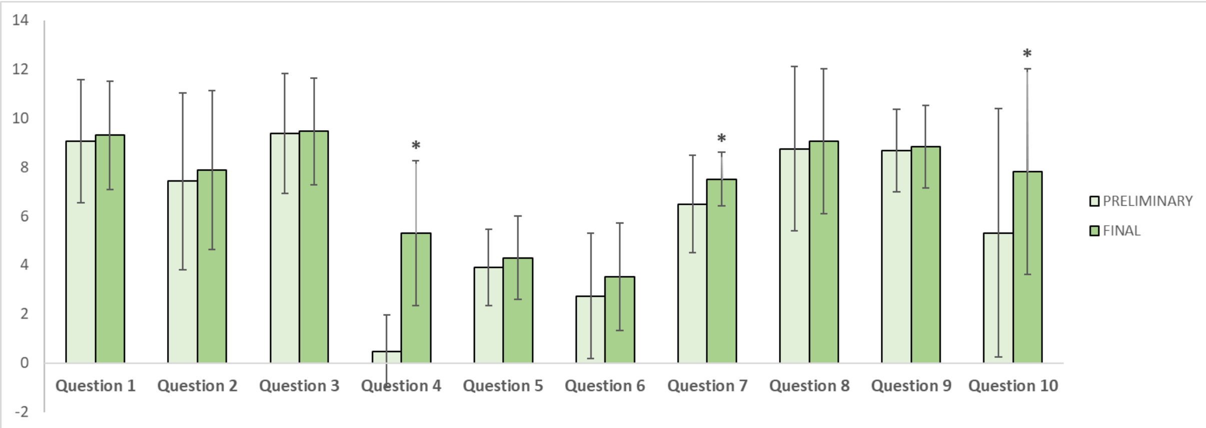
This section shows the results obtained with the university students, before and after the implementation of the scientific dissemination activities (articles and talks) that are part of the project-based learning. The overall results obtained from the pre-training (preliminary) and post-training (final) surveys show how university students significantly improve the total score obtained in the surveys (Figure 2). With regard to the analysis of the scores obtained in each of the questions, it could be seen that after the development of the scientific dissemination activities, a significantly higher score was obtained in questions 4, 7 and 10 (Figure 3).

Figure 2. Final scores obtained by university students in each of the surveys (preliminary survey and final survey).



Source: Poveda Arias, 2022. The data are represented as means in columnar forms, out of 100 (10 points per question), together with their standard deviation in the form of bars. The statistical analysis used was Student's t-test, comparing the results of both surveys with each other.

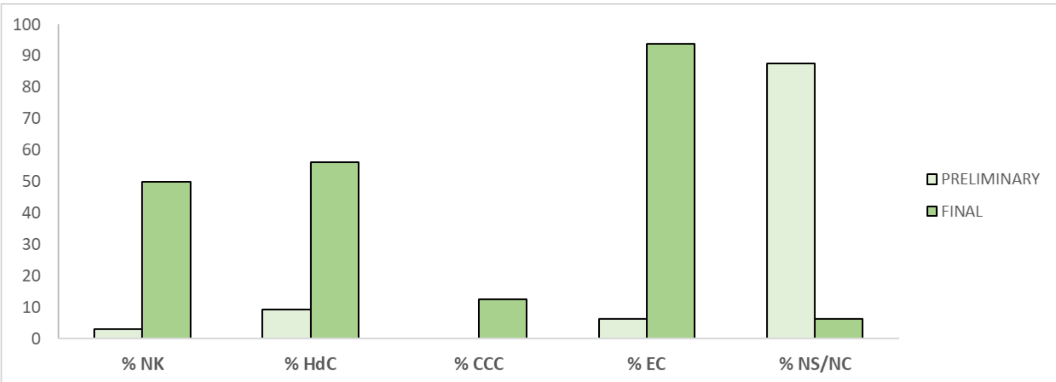
Figure 3. Final scores obtained by university students on each of the questions in the surveys (preliminary survey and final survey).



Source: Poveda Arias, 2022. The data are represented as means in columnar forms, out of 100 (10 points per question), together with their standard deviation in the form of bars. The statistical analysis used was Student's t-test, comparing the results of both surveys with each other.

Question 4 ("Do you know any of the following popular science platforms?") allowed a choice between one or more of the following answers: Naukas (NK), Hablando de Ciencia (HdC), Cuadernos de Cultura Científica (CCC), EspacioCiencia (EC) and No know/No answer (NS/NC). In the preliminary survey, 87% of the students answered NS/NC, some of them knowing the platforms NK (3%), HdC (9%) and EC (6%). In the final survey, only 6% of the students answered NS/NC, with 84% knowing EC, 56% HdC, 50% NK and 12% CCC (Figure 4).

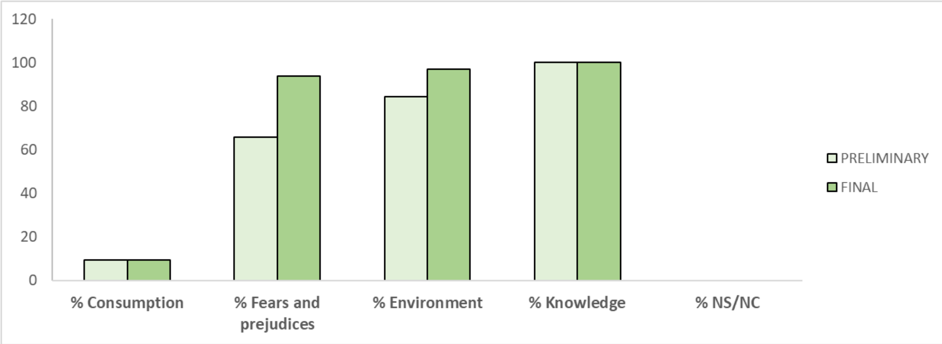
Figure 4. Percentages obtained in the responses to question 4 of the preliminary and final surveys among university students.



Source: Poveda Arias, 2022. The bars represent the response percentages.

Regarding question 7 ("In which of the following aspects do you think science dissemination can change society?"), students could choose one or more of the following answers: "A society based on consumption" (Consumption), "A society with less fears and prejudices" (Fears and prejudices), "A society respectful of the environment" (Environment), "A society based on knowledge" (Knowledge) and NS/NC. In both surveys, 100% of students believe that science dissemination helps the development of a knowledge-based society, and in both surveys, 9% of students believe that it helps the development of a consumer-based society. Regarding the other responses, in the preliminary survey 66% and 84% of students believe that science dissemination helps the development of a less fearful, less prejudiced and more environmentally friendly society, respectively; increasing these percentages in the final survey to 87% and 94%, respectively (Figure 5).

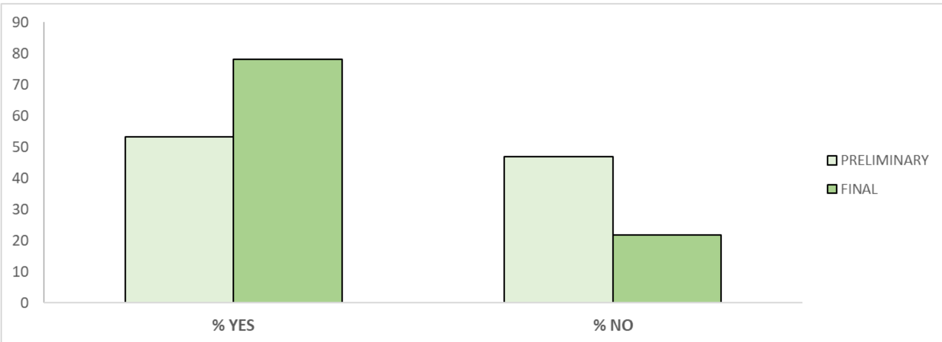
Figure 5. Percentages obtained in the responses to question 7 of the preliminary and final surveys among university students.



Source: Poveda Arias, 2022. The bars represent the response percentages.

Finally, in question 10 ("Do you plan to carry out scientific dissemination work once you have finished your university degree? If yes, which ones?"), in the preliminary survey, 53% of the students answered in the affirmative, while the remaining 47% answered in the negative (Figure 6). The main science outreach strategies reported by students included: social networks, documentaries, interviews, lectures and videos. On the other hand, in the final survey, 78% of the students answered in the affirmative, compared to 22% who answered in the negative (Figure 6). In addition to the strategies already indicated in the preliminary survey, students also consider other strategies, such as podcasts and short articles.

Figure 6. Percentages obtained in the responses to question 10 of the preliminary and final surveys among university students.

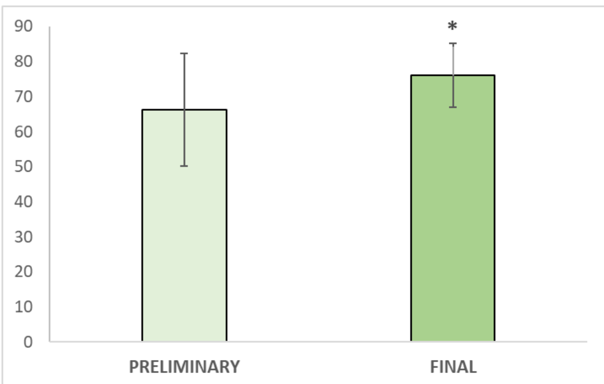


Source: Poveda Arias, 2022. The bars represent the response percentages.

5.2. Pre-university students

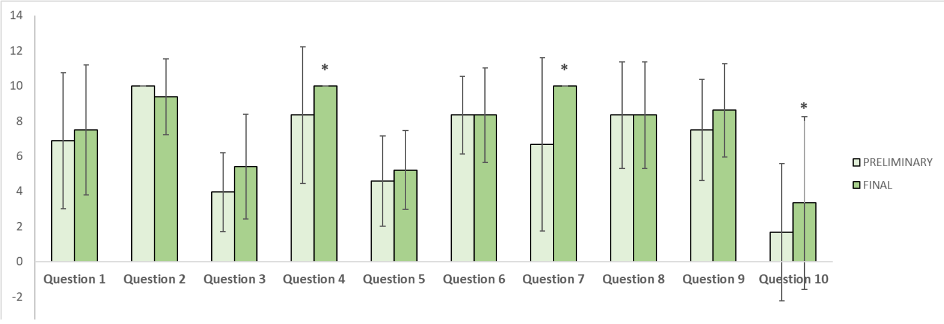
With regard to the results obtained with the pre-university students before (preliminary) and after (final) receiving the science dissemination talks from the university students, it can be seen that the students significantly improved the total score obtained in the surveys (Figure 7). In the individual scores for each question, significantly higher scores were obtained after the lectures (final) only in questions 4, 7 and 10 (Figure 8).

Figure 7. Final scores obtained by pre-university students in each of the surveys (preliminary survey and final survey).



Source: Poveda Arias, 2022. The data are represented as means in columnar forms, out of 100 (10 points per question), together with their standard deviation in the form of bars. The statistical analysis used was Student's t-test, comparing the results of both surveys with each other.

Figure 8. Final scores obtained by pre-university students on each of the survey questions (preliminary survey and final survey).



Source: Poveda Arias, 2022. The data are represented as means in columnar forms, out of 100 (10 points per question), together with their standard deviation in the form of bars. The statistical analysis used was Student's t-test, comparing the results of both surveys with each other.

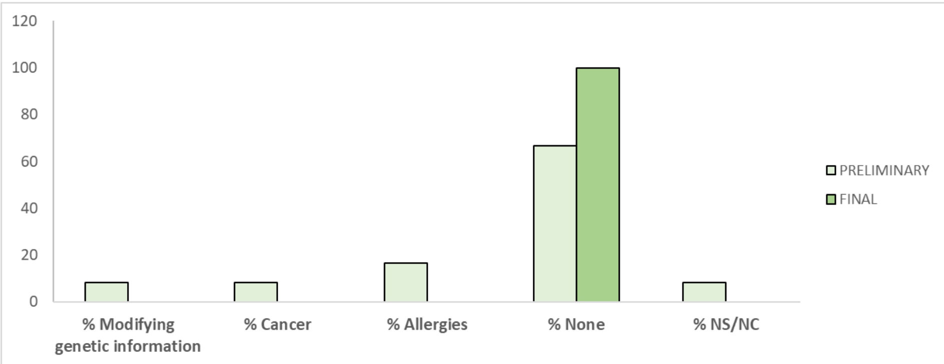
In question 4 ("Is science dissemination by scientists working in public institutions necessary?"), 83% of the students answered "Absolutely necessary", while the remaining 17% selected the answer "Only if they have time left over from their research work" in the preliminary survey. In the final survey, 100% of the students answered "Completely necessary" (Figure 9).

Figure 9. Percentages obtained in the answers to question 3 of the preliminary and final surveys of pre-university students.

Source: Poveda Arias, 2022. The bars represent the response percentages.

Regarding question 7 ("Eating GM plants can..."), in the preliminary survey, 8% of the students answered "Modify your genetic information", "Produce cancer" and "NS/NC", 17% answered "Cause allergies" and 67% "None of the above". After the science outreach lectures on GM plants (final), 100% of the pre-university students answered "None of the above" (Figure 10).

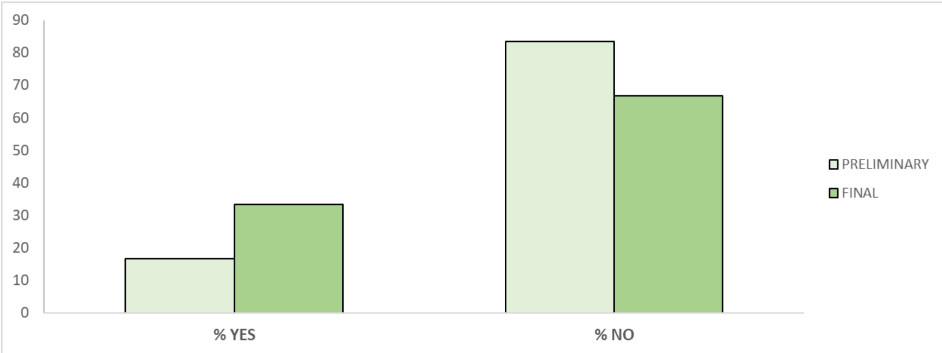
Figure 10. Percentages obtained in the answers to question 7 of the preliminary and final surveys of pre-university students.



Source: Poveda Arias, 2022. The bars represent the response percentages.

In question 10 ("Are you planning to continue your education (university degree or vocational training) in something related to plant biotechnology (e.g. biotechnology, agricultural engineering, food engineering, biology, etc.)? If yes, what do you want to study after the baccalaureate?"), before the (preliminary) lectures 17% of the students answered in the affirmative and 83% in the negative. After the lectures (final), 33% of the students answered in the affirmative and 67% in the negative (Figure 11). In both surveys, all students who answered in the affirmative indicated that they were interested in pursuing university studies in biotechnology.

Figure 11. Percentages obtained in the answers to question 10 of the preliminary and final surveys of pre-university students.



Source: Poveda Arias, 2022. The bars represent the response percentages.

6. Discussion

It has been observed that the elaboration of informative articles and short talks by university students significantly increased the scores obtained in the final surveys (Figures 2 and 3), therefore, having successfully developed autonomous learning on this subject. In this sense, in 2005 it was described how interactive presentations made by students effectively increase knowledge and interest in a given subject (Catalán, 2005), in a similar way to the elaboration of scientific talks, as in this work. Other authors have previously pointed out the importance of developing formative science communication strategies at different educational levels. Mainly, starting from primary scientific literature and being able to communicate it effectively to society in general. In this way, future scientific-technical professionals see the dissemination of science as a routine part of their professional activity (Brownell et al., 2013).

Both the elaboration of articles and science popularization talks entail an important improvement in the communicative skills of university students, having to assimilate and fully understand scientific information that they must then reformulate for the general society in an accessible language. In relation to this, it has been pointed out that many university students are unable to produce fluent and accessible texts and lectures, due to the lack of practice in their training period (Iglesias et al., 2017), an aspect that could be addressed with the training strategies proposed in this work.

The performance of scientific dissemination tasks by scientists and technicians is especially important in rural areas and on topics related to agriculture and food (Kumar et al., 2017). In this sense, universities should train and encourage their students to carry out different scientific dissemination tasks, enabling the development of professionals who are aware of the importance of communicating with society (de Queiroz & Becker, 2016).

Question 4 asked the university students to determine the students' knowledge of different popular science platforms (Figure 4). The results obtained in this question represent a clear example of autonomous learning, as only one of the platforms (EC) was worked on in class. In the surveys prior to the science popularization project, almost 90% of the students did not know any platform. However, after the development of the project, almost 95% of the students were familiar with a platform. These results are a direct consequence of the students' autonomous learning in order to be able to develop the science popularization projects proposed (in this case, science popularization articles), therefore, a consequence of autonomous learning based on PBL. In this way, "the student learns to learn in a creative way supported by autonomous work" (Rodríguez & Bustillos et al., 2017).

Regarding students' opinions and views, question 7 ("In which of the following aspects do you think science popularization can change society?") (Figure 5) shows from the outset the students' awareness of the role of science popularization as a fundamental axis to achieve a society with less fear and harm, more environmentally responsible, and more and better informed (Grillo et al., 2016). However, after the science outreach project, there was a positive change of opinion with regard to achieving a less fearful, less harmful and more environmentally friendly society, due to the greater knowledge gained during the training period.

With regard to the vocation of university students as science popularizers (Figure 6), the PBL developed in ABS awakens students' vocation as science popularizers, once they have finished their university studies, as has been observed by other authors in other fields thanks to the use of ABS (López-Guede et al., 2018). The publication of students' work and its representation to society is a great incentive and a way of highlighting the value of their work, something that greatly favors and encourages their ability to learn about the area and their future related to the skills acquired (Hyland, 2017).

It is noteworthy that the methodology for analyzing PBL in university education is still under development, with surveys being one of the most widely used tools so far (Guo et al., 2020). With respect to biotechnology, the development of PBL in university students has been previously described as a good tool in improving creative thinking skills with respect to flexibility, fluency, originality and elaboration (Atmojo, 2020).

In Spanish pre-university students, knowledge regarding biotechnology is good and the attitude towards its applications is generally positive, being especially interested in the use of biotechnology for the improvement of the environment and the development of medical applications (López-Banet et al., 2020). However, this knowledge could be increased by developing learning methodologies other than lectures and laboratory classes (Hin et al., 2019), for example, through case studies or research designs (Tikhomirova, 2020). In this regard, science popularization lectures improved the biotechnology and science popularization knowledge of pre-university students (Figures 7-10).

Several authors have previously stated that activities outside the classroom need to be developed to promote the acquisition of scientific-technical knowledge by pre-university students (Bell et al., 2003; Braund & Reiss, 2006). In this sense, science talks have been proposed as a good learning strategy (Zhang et al., 2010), even more so if it allows the development of scientific discussions between students and speakers (Castano, 2008; Clarke et al., 2016).

Finally, in our study we have been able to determine how scientific talks on plant biotechnology provide an incentive for pre-university students to pursue higher studies in biotechnology (Figure 11). A previous study has already determined how the approach of the university community to pre-university students significantly favors positive attitudes towards a particular higher education study (Aschbacher et al., 2010; Hazari et al., 2010).

7. Conclusions

Through the use of science dissemination PBL we have been able to develop autonomous learning in undergraduate students of plant biotechnology. Without having taught science popularization content in the classroom, the students were able to acquire specific knowledge on the subject through autonomous research. Therefore, the use of science popularization PBL represents a good strategy for the development of autonomous learning in university students.

As has already been stated throughout this work, it is very necessary to bring complex scientific knowledge closer to society, so that citizens are informed and can make the best decisions. With the current perception of plant biotechnology by the public, this becomes even more necessary in the field of transgenic plants. In this sense, we have been able to verify how the development of science dissemination PBL with university students favors the development of vocations as scientific disseminators. This aspect is very important, since it represents a didactic strategy that has a great impact on the professional careers of university students and, above all, on society in general.

Dissemination talks are the most widely used face-to-face strategy for scientific dissemination. It is a close, clear and accessible way to disseminate scientific knowledge to different audiences. In addition, it represents one of the results of the science dissemination PBL developed by university students in this work. These science dissemination talks were given to pre-university students, demonstrating how they were able to increase the knowledge of plant biotechnology and science dissemination in this group. Therefore, science dissemination talks conducted by university students for pre-university students represent a good strategy for knowledge transmission and learning.

In the current situation of population growth, it will be necessary to increase agricultural production in order to feed the future population. Transgenic plants are one of the most promising strategies for this purpose. However, specialized personnel are needed for their development, management and risk analysis. In this sense, it is important to promote professional and academic vocations in plant biotechnology among pre-university students. In this work we have been able to verify how science dissemination talks by university students on plant biotechnology promote the future choice of biotechnology-related university degrees among pre-university students. This is a fundamental aspect for the future of the world population.

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