

EVALUATION OF A COURSE ON ETHICS IN THE STEM AREA: THE CASE OF TECNOLÓGICO NACIONAL DE MÉXICO CAMPUS TLÁHUAC

EVALUATION OF A COURSE ON ETHICS IN THE AREA OF STEM: NATIONAL TECHNOLOGICAL CASE OF MEXICO CAMPUS TLÁHUAC

Estrella Evelyn Armenta-Verdugo, Jorge Alberto Olayo-Valles, Griselda Ramírez-Castillejo³, Domingo Noé Marrón Ramos⁴.

¹ Master's Degree in Quality. Tecnológico Nacional de México-Instituto Tecnológico de Tláhuac, Departamento de Ciencias Económico Administrativas. estrella.armenta@tlahuac.tecnm.mx, (55) 5841-0560 Estanislao Ramírez #301 Ampliación Selene, C.P. 13430 Tláhuac, Mexico City.

² Master's Degree in Educational Innovation and Technology. Tecnológico Nacional de México-Instituto Tecnológico de Tláhuac, Departamento de Ciencias Económico Administrativas. jorge.olayo@tlahuac.tecnm.mx, (55) 5841-0560 Av. Estanislao Ramírez #30, Ampliación Selene, C.P. 13430, Tláhuac, Mexico City.

³ Bachelor's Degree in Communication Sciences. Tecnológico Nacional de México-Instituto Tecnológico de Tláhuac. Department of Economic and Administrative Sciences. griselda.ramirez@tlahuac.tecnm.mx. (55) 5841-0560. Estanislao Ramírez Ruiz # 301 Ampliación Selene, C.P. 13430 Tláhuac, Mexico City.

⁴ Master's degree in Science. Tecnológico Nacional de México-Instituto Tecnológico de Milpa Alta, Department of Basic Sciences, dmarron22@hotmail.com, (55) 5862-3757 Independencia Sur No. 36, Col. San Salvador Cuauhténco, C.P. 12300, Milpa Alta, Mexico City.

Abstract -- Given the scarce number of studies on the teaching of ethics in programs in the area of science, technology, engineering and mathematics, better known as STEM, as well as the non-existence of studies on such teaching in the Tecnológico Nacional de México (TecNM), this research deals with the results obtained in an evaluation exercise of a subject on ethics, in students from different groups of a program in the area of STEM, of the TecNM Campus Tláhuac.

By means of a quantitative and longitudinal methodology, the present research consisted of applying a questionnaire at the beginning and at the end of the semester to four different groups of students of the same career, belonging to the STEM knowledge area, whose results were analyzed by means of a paired t-test of two samples, to compare the values of the mean number of correct answers obtained and the value of the standard deviation of each of the two applications of the questionnaire.

The results obtained show that the mean number of correct answers obtained in the final application is higher, and that the standard deviation is lower than the results obtained in the initial application, both globally considering the total number of students, and in the particular case of three of the four groups evaluated.

In conclusion, the results obtained show a positive impact on the performance of the students, which can be used to support a more detailed study of the training received by the teachers who taught the course in these four groups, as well as the contents, methodologies and strategies that were used in the delivery of this course in the four groups mentioned.

All of the above with the purpose of contributing elements of experience with respect to the teaching of ethics STEM programs, specifically in the context of the TecNM, in order to achieve an improvement in such teaching, to contribute those that may result as good practices, and to consolidate the quality in the teaching of ethics, both in the TecNM, as well as in all educational programs in the STEM area.

Keywords: ethics education, engineering ethics, ethics assessment.

Abstract -- Given the scarce number of studies on the teaching of ethics in programs in the area of science, technology, engineering and mathematics, better known as STEM, as well as the lack of studies on such teaching at the Tecnológico Nacional de México (TecNM), this research deals with the results obtained in an evaluation exercise of a subject on ethics, in students from different groups of a STEM area program, of the TecNM Campus Tláhuac. By means of a quantitative and longitudinal methodology, this research consisted of applying a questionnaire at the beginning of the semester period and at the end of it, to four different groups of students of the same career, belonging to the STEM area of knowledge, whose Results were analyzed by means of a two-sample paired t-test to compare the values of the mean of correct answers obtained and the value of the standard deviation of each of the two applications of the questionnaire.

The results obtained show that the average number of hits obtained in the final application is higher; and that the standard deviation is lower than the results obtained in the initial application, both globally considering the total number of students, and in the particular case of three of the four groups evaluated.

In conclusion, the results obtained show a positive impact on the performance of the students, with which a more detailed study can be based, both on the training received by the teachers who taught the course in these four groups, as well as on the contents, methodologies and strategies that were used in the teaching of this course in the four groups mentioned.

All of the above in order to provide elements of experience with respect to the teaching of ethics in STEM area programs, specifically in the context of the TecNM, to achieve an improvement in said teaching, to contribute what may result as good practices, and consolidate the quality in the teaching of ethics, both in TecNM, as in all educational programs in the STEM area.

Key words: Teaching of ethics, engineering ethics, ethics evaluation.

INTRODUCTION

Since the beginning of the 21st century, there has been a worldwide trend among higher education institutions (HEIs) to assume, among their objectives, the training of citizens responsible for the problems of their society [1], with intention that their graduates have the ability to practice their profession ethically, however this is defined. This phenomenon does not respond to a single motivation. Ethical reasoning and decision making are highly desired skills among employers, and are considered fundamental to a candidate's potential for career success [2]. Furthermore, it is a fact that the need for citizens who are equipped to practice ethical reasoning and make better decisions is imperative; specifically when faced with the types of ethical scenarios that become news scandals of malpractice, as well as in more everyday ethical scenarios of their own professional endeavors [3] [4].

There is currently a large number of studies and research that demonstrate that ethics can be successfully taught to students in programs diverse knowledge areas, therefore, it is considered that the discussion about whether ethics can be taught or not, has been overcome with a clear affirmative answer, so that reflection and research now focus on delimiting the objectives, methods and best practices for teaching ethics [5] [6] [6] [7] [8].

Problem statement.

While it is clear that there is already a good number of studies and research on the teaching of ethics in various higher education programs, has

This is explained by the fact that it is precisely in the field of bioethics that this new impulse to include the teaching of ethics in higher education has originated [1], so it is clear that there is more information about the teaching of ethics in the area of health sciences, such as medicine, nursing, biology and genetics.

In addition, it was found that of the total number of articles published in the 9 issues of the International Journal of Ethics Education, all of which refer in some way to the teaching of ethics, only one of 62 articles explicitly refers to the teaching of ethics in an area of knowledge related to science, technology, engineering and mathematics (STEM), which represents less than 2% of the total number of articles published. Likewise, in a study conducted by Avci [5], out of a total sample of 26 articles reviewed, which were obtained by searching for the phrases "ethics education", "ethics teaching" and "ethics learning", only 1 of the 26 articles reviewed refers to the teaching of ethics in a STEM-related program, which represents less than 4% of the total number of articles reviewed.

Therefore, the problem that motivates the present research work is the lack of information that exists regarding the teaching of ethics in programs in the STEM knowledge area, and more specifically the lack of information that exists about the teaching of ethics in TecNM programs.

General Objective

To analyze the results obtained in the evaluation process of the subject Ethics Workshop, carried out in four groups of the Architecture career of the Tecnológico Nacional de México campus Tláhuac, in order to contribute to the discussion about the teaching of ethics in STEM programs.

Specific Objectives

- Apply an evaluation questionnaire for the Ethics Workshop course, at the beginning of the period. semester, in the four groups.
- To teach the subject Ethics Workshop based on the official syllabus of said subject, during the six-month period.
- Apply the same evaluation questionnaire, to the same four groups, at the end of the semi-annual period.

- Analyze the results obtained in order to compare best practices and criteria for quality in ethics teaching, found in the literature.

Theoretical Framework

With respect to the teaching of ethics, there are different positions regarding the best way to carry out such teaching. A first distinction that should be taken into account is that between teaching ethics by teaching a specific course on ethics, and teaching ethics by including ethical issues within the courses of the educational program's own subjects [9] [10] [11]. As examples of the implementation of including ethical topics and reflection within the subjects of educational programs, we can mention the *Ethics across the curriculum* program of the Illinois Institute of Technology [12]; the *Embedded EthiCS* program of Harvard University [13] and the Group for Innovation in Values Education in Scientific and Technical Studies of the Polytechnic University of Valencia [14]. Although the reality is that the vast majority of higher education institutions have chosen to include a specific course on ethics, as is the case of the Tecnológico Nacional de México.

Within the institutions that have opted for a specific course on ethics, there are still some distinctions that should be mentioned. For example, in some institutions, the course on ethics is optional, while in others it has been made mandatory for all students in all educational programs [15]. Likewise, another distinction that should be noted is that there are institutions that, in addition to their face-to-face course, have also implemented resources available online to complement the training of their students [16] [17]. Regarding the methodologies implemented to measure the efficacy or effectiveness of ethics teaching, for the present research the experience of longitudinal studies is taken up, which consist of the application of evaluation instruments in at least two different moments, in which the teaching of a course on ethics between the two moments of the application of evaluation is always in between [18] [3]. In this regard, it is important to clarify the difference between evaluating the performance and evaluating the effectiveness of a course; performance refers to whether a course is successfully implemented, while effectiveness refers to whether the results of an implemented course are effective, in the sense of whether the acquired knowledge remains with the students long after they have taken the course [3] [19]. From

Thus, the present project is a study on the performance achieved in the teaching of the Ethics Workshop course.

Justification

Although the importance of teaching ethics in STEM programs is recognized, it can still be perceived that, in general, the way in which higher education institutions have approached the teaching of ethics is not fully consolidated, and even in some cases the implementation of such teaching still seems to be done in a somewhat intuitive way [20] [21].

Although it is possible to find information of a much more concrete and specific nature regarding the contents, didactic strategies and results obtained through the concrete application of a form of teaching ethics in programs in the area of health sciences, this is not what happens with the teaching of ethics in programs in the area of STEM, and this is one of the motivations for carrying out the present project. Likewise, given the relevance of the impact that the professional activity of engineers has in today's world, it is important to study the results obtained with specific strategies for teaching ethics in programs in the STEM area [22]. Particularly if the research can contribute something with respect to the teaching of ethics in TecNM programs, in which the strategy of including a specific course on ethics, mandatory for all students, in all undergraduate level programs since 2004 was implemented [23], which is a measure of enormous impact, considering that 92% of the 41 educational programs of the TecNM belong to the STEM area, about which there are no reports or studies that show the results obtained, so any research that seeks to trigger discussion the concrete experiences of teaching ethics in the programs of the STEM area of the TecNM is necessary and fully justified.

DEVELOPMENT

For the present study, the questionnaire applied was designed by one of the researchers and validated by a group of teachers who are experts in teaching the subject "Ethics Workshop", using the Delphi method, understood as a process of iterative and anonymous evaluation [24] of each of items of the questionnaire by the expert teachers. Subsequently, the reliability of the instrument was calculated by means of Kendall's concordance coefficient [25], which measures

the degree of concordance between each item and the content of the curricular program of the subject to be evaluated. For this purpose, each expert is required to evaluate each item in terms of four aspects: sufficiency, clarity, coherence and relevance. In the case of the instrument used, a concordance coefficient was obtained with a value of 0.902676.

It is worth mentioning that the questionnaire that was applied is part of an Educational Research project that is currently under development, whose intention is to submit the questionnaire to a national validation, in order to consolidate an instrument to evaluate the performance of students in the Ethics Workshop course, in all the programs of the Tecnológico Nacional de México.

Since the intention of the present work is to characterize the phenomenon of the evaluation of the subject Ethics Workshop, the methodology used was descriptive [26]. Due to the type of data used, namely, the number of successes obtained, the mean and the standard variation, the present study can be classified as a quantitative study. The present research can also be classified as longitudinal since data were obtained by measuring the outcome variable, which in this case is the number of correct answers obtained by four groups of Architecture students in the Ethics Workshop course in two applications that occurred at different times: one at the beginning and the other at the end of the semester, with the purpose of analyzing its variation. This outcome variable is considered as a dependent or related variable, since the two samples of number of correct answers were taken from the same individual students at the beginning and at the end [27]. The questionnaire consisted of 7 multiple-choice questions based on the syllabus of the subject, with only one correct answer for each item.

It is important to note that the Ethics Workshop was taught by a different teacher in each of the four groups considered. However, all teachers have received training to teach this subject specifically. This is relevant because it has been documented that one of the most significant problems regarding the teaching of ethics is the lack of trained teachers [28] [29] [30] [31].

Therefore, once the semester began, the questionnaire was applied to obtain the initial sample of the four groups. Afterwards, the Ethics Workshop was taught in the four groups, and at the end of the semester, the questionnaire was applied to the four groups.

the questionnaire again to obtain the second sample.

Subsequently, we proceeded to carry out a filtering process of the data obtained. This is due to the fact that, if any student was absent during either of the two moments of application, it is not possible to take his or her result into consideration, since in longitudinal studies both results must be available to make up the two related samples. In this filtering process, there was a total of 85 students who presented at least one evaluation, and a of 34 were discarded; of which 21 corresponded to students who only presented the initial evaluation, and 13 corresponded to students who only presented the final evaluation. This means that 40% of the students who presented at least one of the evaluations were discarded; however, it should be taken into account that, in the initial week of the semester period, some enrolled students do not attend the first classes, and some few are assigned to their groups in processes of extemporaneous re-enrollment, so 13 students absent from four groups is not something exceptional. However, it should also be considered that by the end of the semester period in which the evaluations were carried out, on-site classes were suspended due to the Covid-19 pandemic. Thus, in addition to the ever-present dropout rate, in this case the Tecnológico authorities offered the student community the possibility of cancelling the semester, in response to technical, economic or health complications, which could prevent students from continuing with their online classes; hence, 21 students only took the first evaluation. Thus, the final sample to be analyzed consisted of the initial and final results of 51 students.

Once the data had been cleaned, the analysis process began, using the paired t-test for related samples, which allows determining whether there is a statistically significant difference between the results of the two evaluations [32]. The way it works is by comparing two averages with normal distribution of a related sample, that is, the mean of the number of correct answers of the initial application is compared with the mean of the number of correct answers of the final application, of exactly the same students.

The null hypothesis (H_0) with which we work is: there is no difference in the mean number of correct answers in the initial application, with the mean number of correct answers in the final application, of the students who took the Ethics Workshop.

To carry out the paired t-test, the MiniTab software was used, which shows the values of the means of each of the applications, as well as the value of the standard deviation between the results of all the students considered in both applications.

Finally, the same paired t-test was performed with the initial and final evaluations of each of the four groups, in order to observe the values corresponding to each of the groups separately, and to better understand the results obtained.

DISCUSSION AND ANALYSIS OF RESULTS

When the paired t-test was performed with the total of the initial and final evaluations of the four groups, the results obtained are shown in Table 1:

Table 1. Results of the overall paired t-test.

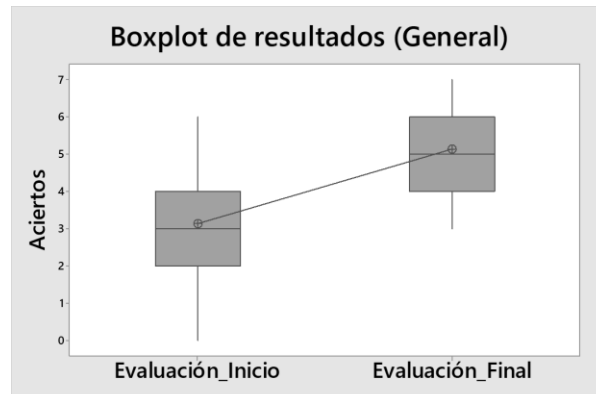
	N	Media	StDev	SE Media
Evaluation at start-up of the course	51	3.14	1.37	0.19
Evaluation at the end of the course	51	5.14	1.15	0.16

Source: Own elaboration.

The N column refers to the number of students assessed; the Mean column refers to the value of the mean calculated from the total number of responses in each of the two assessments; the StDev column refers to the value of the standard deviation that each assessment has.

As can be read, the value of the mean of the final evaluation is higher than the value of mean of the initial evaluation, which means that, on average, the students obtained a higher number of correct answers in the final evaluation than the number of correct answers they obtained in the initial evaluation.

To observe more clearly this difference between the means of both evaluations, Figure 1 was prepared, which is a Boxplot type graph, in which the point inside each box indicates the value of the mean of each evaluation, in relation to the Y axis that shows the number of correct answers, in addition to the fact that the line that joins both points shows graphically the increase in the mean of the final evaluation with respect to the mean of initial evaluation:



Boxplot plot of all results.

Source: Own elaboration.

To understand in more detail what this means, it is relevant to mention the P-value obtained in this paired t-test. Understanding that the P-value measures the probability that any observed difference between samples is due to chance. So values close to 0 indicate that the observed difference is unlikely to be due to chance [33].

Thus, for the paired t-test with the total number of students in the four groups evaluated, a P-value of 0.000 was obtained, or as commonly represented $P < 0.05$, and what this means, is that the results obtained are not due to any random factor, but that the teaching of the course on Ethics, had a statistically significant effect on the results obtained by the students in the final evaluation.

On the other hand, it can be observed that the value of the standard deviation is lower in the final evaluation than in the initial evaluation, which means that, in general, there was a smaller difference between the results obtained by the students in the final evaluation than the difference between the results obtained in the initial evaluation.

Figure 2 shows more clearly the difference between the deviation of one evaluation and the other, by means of a graph of individual values, where the rows of dots show the way in which the results obtained individually in both evaluations are grouped:

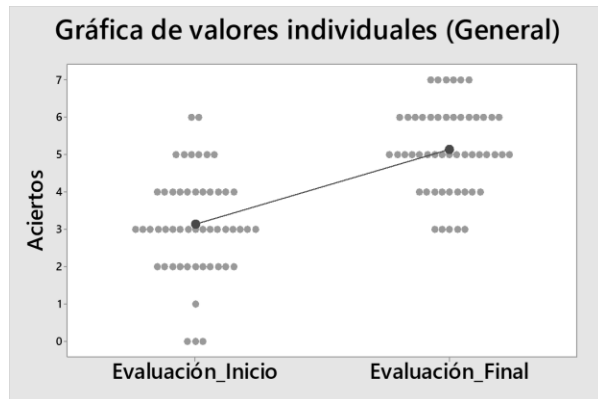


Figure 2. Graph of individual values of all results.
Source: Own elaboration.

As can be seen, the set of items in the final evaluation is more compact than that of the initial evaluation. This corroborates the idea that the impact of the ethics course is significant, if we understand that the standard deviation is the standard deviation or average between the individual scores in a distribution and the mean of the distribution [34]. Then, in the context of the average number of correct scores obtained in an evaluation, a lower deviation implies that the performance of the set of students is more homogeneous, with fewer singularities such as those one might expect to find in an initial evaluation. This shows that, by the end of the course, after having worked on the topics of the ethics course, the performance of the students in the final evaluation is more regular and homogeneous, with a higher mean, and a lower standard deviation of that mean, as is expected in the performance of students who manage to accredit a subject. Similarly, the paired t-test was carried out with the results of each group separately. For this purpose, and for the purposes of this research, we will refer to the four groups evaluated as group A, group B, group C and group D. With respect to group A, the results shown in Table 2 were obtained:

Paired t-test results for group A

	N	Media	StDev	SE Media
Evaluation at start-up of the course	14	3.14	1.70	0.46
End-of-course evaluation	14	4.43	1.02	0.27

Source: Own elaboration.

These results can be seen graphically in Figure 3:

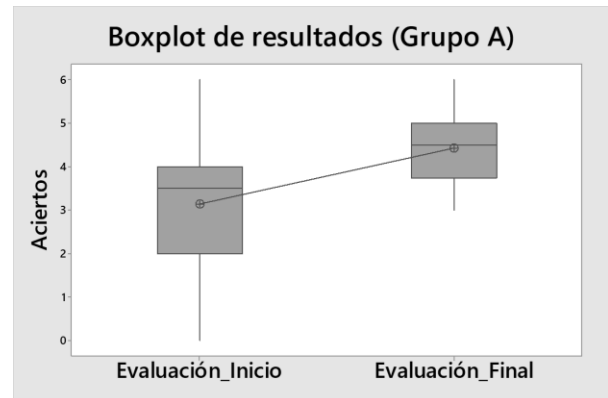


Figure 3: Boxplot plot of group A results. Source: Own elaboration.

As can be seen, the line that goes from the value of the mean of the initial evaluation to the mean of the final evaluation also shows an increase.

Likewise, regarding the standard deviation, its graphical representation can be seen in Figure 4:

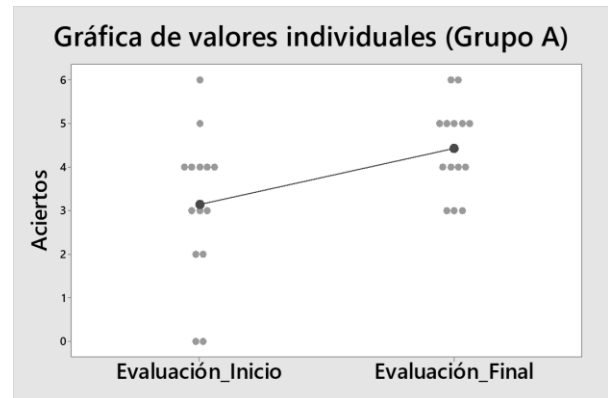


Figure 4: Individual value plot of group A results.
Source: Own elaboration.

So, having a higher mean and a lower standard deviation in the final evaluation with respect to the initial evaluation, it can be said that the teaching of the course on ethics had a statistically significant impact on group A specifically, which is corroborated by the P- value of 0.024, i.e. $P < 0.05$, so it is unlikely that these results are caused by chance, but were caused by the effect of the course taught.

With respect to group B, the results obtained were as follows, as shown in Table 3:

Paired t-test results for group B

	N	Media	StDev	SE Media
Evaluation at the beginning of the course	21	2.86	1.20	0.26
Evaluation at the end of the course	21	5.38	1.07	0.23

Source: Own elaboration.

To better appreciate the difference between the means of each of the evaluations, it can be seen in Figure 5:

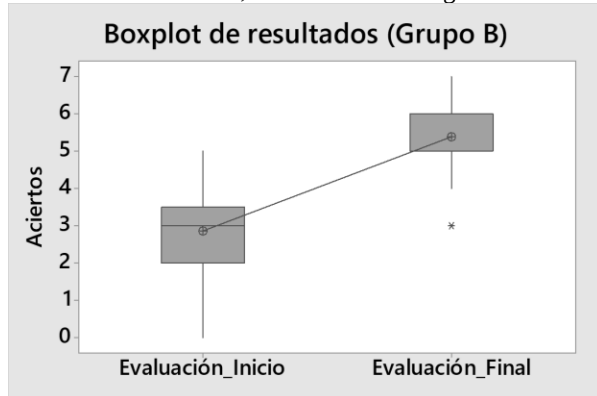


Figure 5: Boxplot plot of group B results. Source: Own elaboration.

As can be seen, the line clearly shows an increase in the mean of the final evaluation, as the difference is 2.52 hits. Similarly, we can graphically observe the standard deviation of group B in Figure 6:

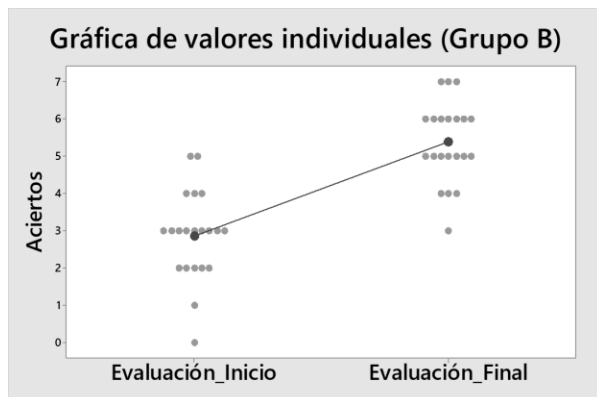


Figure 6: Individual value plot of group B results. Source: Own elaboration.

We have then, that the result shows the same, with a P-value of 0.000, that is, that $P < 0.05$, therefore, the ethics course in this group, also generated an improvement in the result obtained by the students in the final evaluation, and the improvement in the value of the mean of the final evaluation, is unlikely to be the product of chance.

Continuing with the analysis, the results of group C are shown in Table 4:

Results of the paired t-test for group C.

	N	Media	StDev	SE Media
Evaluation at the beginning of the course	21	2.86	1.20	0.26
Evaluation at the end of the course	21	5.38	1.07	0.23

Source: Own elaboration.

In this regard, Figure 7 shows graphically the difference between the means of one evaluation and the other in group C:

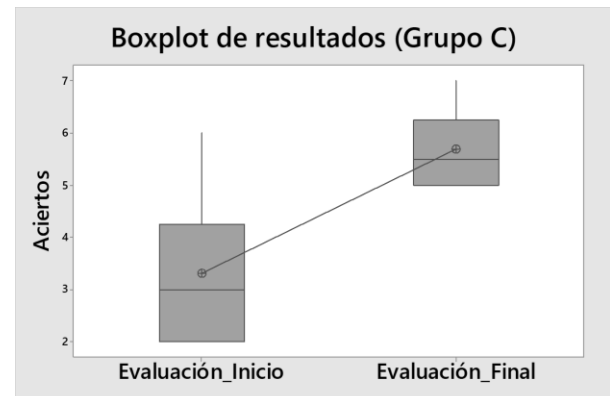


Figure 7: Boxplot plot of group C results. Source: Own elaboration.

Similar to the general trend and that of groups A and B, the line showing the increase in mean of the final evaluation is also observed in group C, since the difference between the two means is 2.52.

Regarding the standard deviation, in Figure 8 we can observe the grouping of the results obtained by each student of group C:

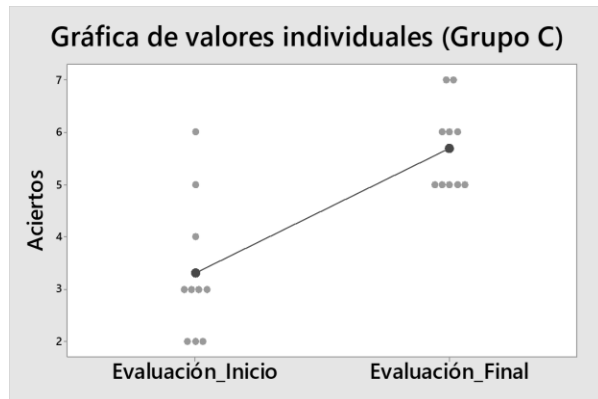


Figure 8. Graph of individual values of group C results.
Source: Own elaboration.

Thus, the result of the other groups is reiterated, with a P-value of 0.000, which is located in the range of the condition $P < 0.05$, thus confirming that the delivery of the course managed to have an impact on the improvement of the results obtained in the final evaluation, with a higher mean number of correct answers, and with a more homogeneous performance by reducing the standard deviation, compared to the initial evaluation.

Finally, the results corresponding to group D are shown in Table 5:

Results of the paired t-test for group D.

	N	Media	StDev	SE Media
Evaluation at start-up of the course	6	3.83	1.17	0.48
End-of-course evaluation	6	5.00	1.55	0.63

Source: Own elaboration.

As with the other three groups, these results can be seen in the boxplot in Figure 9:

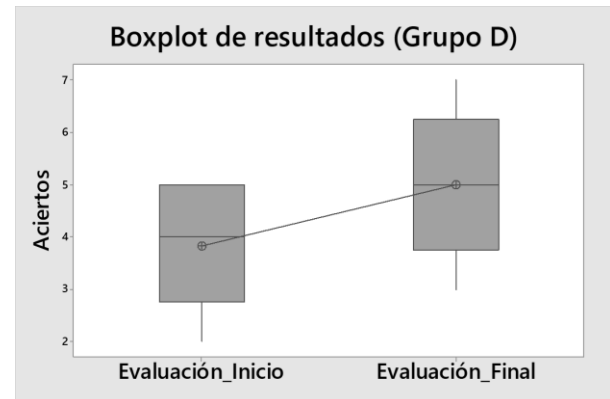


Figure 9. Boxplot plot of the results of group D. Source: Own elaboration.

Likewise, the relationship shown by the line between the means of both evaluations confirms that that of the final evaluation is greater than that of the final evaluation.

However, unlike the other three groups, the standard deviation of the final evaluation is not less than the standard deviation of the initial evaluation, shown in Figure 10:

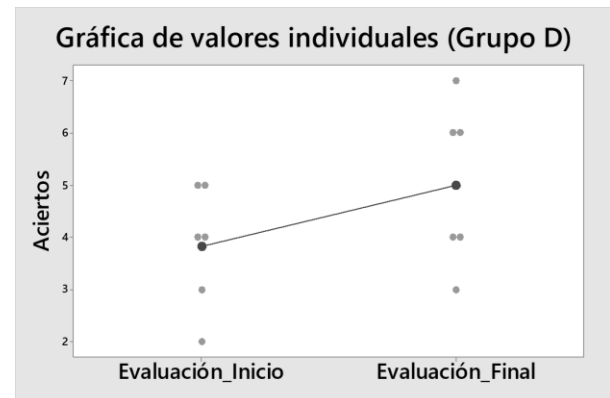


Figure 10. Graph of individual values of group D results.
Source: Own elaboration.

In this case, although the difference between standard deviation increased, the difference between the means of both evaluations shows the improvement in the result the final evaluation, with a P-value of 0.175, still complying with the condition of $P < 0.05$, so the improvement in the mean number of correct answers was not due to chance, but to the effect of the course, although this improvement is not observed homogeneously among the students in this group, only some of them increased their number of correct answers, and others did not.

CONCLUSIONS

It can be concluded that the present evaluation exercise of the ethics course was successful, since the results obtained show that the teaching of the course had a positive impact on the results obtained by the students in the final evaluation. This should be taken into account as a significant contribution to the study of the teaching of ethics at the Tecnológico Nacional de México, as well as to the study of the teaching of ethics in STEM programs. Undoubtedly, one of the immediate subsequent studies should address the design of the instrument with which the initial and final evaluations of the ethics courses are being carried out. In this regard, we can comment that we are currently working on the validation process of an instrument to evaluate the Ethics Workshop course at TecNM.

In addition to this, it is important to continue evaluating the results obtained by the four teachers who participated in this research, because except one, their training profile is not specifically related to the study of ethics, which leads to carry out research on the impact of the training received by these teachers. This leads to carry out research on the impact of the training received by these teachers, in order to support a proposal that can be applied at national level within the TecNM, because as has already been found in previous research, one of the main problems regarding the teaching of ethics at national level in the TecNM is the appointment of teachers who do not have a related profile and who have not received any training to teach the subject in question.

It is also pertinent to inquire more specifically about the contents, methods and teaching techniques implemented by the teachers of these four groups studied, as well as the successful experiences of other institutions on the teaching of ethics in STEM programs, since that is the contribution to the field of knowledge on education, to recover good practices, apply them, analyze the results obtained and inform the world community of any experience with effective results.

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