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TEACHING OF ETHICS IN ENGINEERING UNDERGRADUATE PROGRAMS: TECNOLÓGICO NACIONAL DE MÉXICO'S CASE

ENSEÑANZA DE LA ÉTICA EN PROGRAMAS DE PREGRADO DE INGENIERÍA: EL CASO DEL TECNOLÓGICO NACIONAL DE MÉXICO

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ABSTRACT

Considering the huge boom that the integration of ethical notions in college education has had in universities around the world, this work is a research about this process in Mexico's National Tech (TecNM). It specifically looks into the training of teachers who teach the Ethics Workshop subject in the TecNM, given its traditional vocation to train almost exclusively engineers. Through a nationwide survey of the areas responsible for assigning teachers who teach the subject in question, it turns out that only 68% of these teachers have a related profile or have been trained to teach the Ethics Workshop. This shows that it is necessary to implement some strategy to improve the training of these teachers, and thereby reaffirm the importance of integrating ethical notions in the training of engineering students of the TecNM.

Key words: Engineering ethics, teaching of ethics.

RESUMEN

Teniendo en cuenta el enorme auge que ha tenido la integración de las nociones éticas en la educación universitaria en las universidades de todo el mundo, este trabajo es una investigación sobre este proceso en el Tecnológico Nacional de México (TecNM). Se ocupa específicamente de la formación de los docentes que imparten la asignatura de Taller de Ética en el TecNM, dada la tradicional vocación de formar casi exclusivamente ingenieros. A través de una encuesta a nivel nacional de las áreas responsables de asignar maestros que enseñan el tema en cuestión, resulta que solo el 68% de estos maestros tienen un perfil relacionado o han sido capacitados para enseñar el Taller de Ética. Esto demuestra que es necesario implementar alguna estrategia para mejorar la formación de estos docentes y, por lo tanto, reafirmar la importancia de integrar nociones éticas en la formación de los estudiantes de ingeniería del TecNM.

Palabras clave: ética de la ingeniería, enseñanza de la ética.

INTRODUCTION

Since the beginning of the XXI century there has been a worldwide tendency among higher education institutions (HEI), to assume, among its objectives, to train citizens responsible for the problems of their society (Bolívar, 2005). The main intention behind this is to promote in their graduates the capability of practicing their professions ethically, however this may be defined.

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For the purposes of this study, the discussion about whether ethics can be taught or not has been overcome. Not only is it a necessity, but there are already so many studies and favorable experiences that it has been clearly demonstrated that it can be taught. That is why the reflection and research efforts are currently focused on which is the best way to do it (Echeverría, 2013) (Gómez & Royo, 2015) (Martínez, Buxuarrais & Esteban, 2002).

It is important to point out that there are different strategies being implemented in order to achieve this goal: some institutions have chosen to rely on extracurricular activities to foment the ethical exercise of their profession when they graduate (Rodríguez, Pantoja & Salazar, 2010); other institutions have designed more complex and thorough strategies such as *ethics across the curriculum* in which the Illinois Institute of Technology worked out with all their professors, even those of the more technical subjects, to include ethical reflections within each of their courses (Davis, 1994); in a similar way, programs like *Embedded EthiCS* on Harvard University, have integrated philosophers and ethics reasoning into some of their Computer Science courses, in order to have their students address this topics as a core aspect of their profession (Harvard University, s.f.); and the most commonly used strategy, which is to include a course specifically about ethics.

However, even among those institutions who have chosen to include a course about ethics, there are a few differences in the way they do it: most of them offer an elective ethics course which their students may choose to take or not, while some have an ethics course which is mandatory for all their undergraduate students (Hirsch, 2004).

Such is the case of the Tecnológico Nacional de México (TecNM). Coincidently with the tendency mentioned at the beginning, since the year 2004, TecNM modified all its 41 undergraduate programs to include a mandatory course called *Ethics Workshop* (Taller de Ética by its name in Spanish), in accordance to an update in their educational model (Gamino & Acosta, 2016). However, there has been no proper study or evaluation about the effectiveness or the way this strategy has been implemented, and given the fact that TecNM is conformed by 254 campuses located throughout the Mexican territory, and that it attends more than 600,000 higher education students, the implementation of this strategy is worthy of an analysis.

In addition to this, given the relevance of the impact that the professional activity of engineers have in today's world, there are already many studies about ethical responsibility in engineering, from which it has been made clear that there's an imperative need to incorporate the ethical aspect in the training of these professionals, in order to make them capable of facing moral dilemmas in the exercise of their profession (Félix, 2013) (Gurruchaga, Moras, Gurruchaga, & Barradas, 2011).

There for, the objective of this research is to obtain a diagnosis about the way in which this subject is taught, specifically about the profile and the training regarding ethics, that the professors who teach this course have had.

RESEARCH MATERIALS AND TECHNIQUES

This has been proposed as a descriptive investigation, with the intention of forming a diagnostic approach, about the way in which TecNM has being implementing its strategy to integrate ethics into its engineering student's education. In order to do so, information was collected using the survey technique. Through an online questionnaire instrument, conformed by 4 items which required solely the quantity of professors as described in each item, as well as 5 items for the compilation of some simple statistical indicators

regarding each Institute. The information collected was obtained from a sample of 43 Institutes, which represent 17% of the total population of 254 Institutes. No sampling technique was applied, since the questionnaire was sent to the total of the Institutes that conform the TecNM, and the sample corresponds to the total of Institutes that responded.

Some limitations during the survey process were not being able to confirm that those responsible for the academic department (DCEA for its name in Spanish), in which professors who teach the Ethics Workshop are assigned, did received the survey through their institutional email account; likewise, the other limitation was the response time or the unwillingness to respond.

The information requested in the questionnaire was the total number of professors who taught the subject Ethics Workshop, in the periods January-June and August-December 2018; and out of those professors, the total number of them who do have an adequate profile to teach the Ethics Workshop; and out of the ones who don't, the total number of professors who had received any kind of training to teach the subject in question.

It should be noted that in order to avoid interpretation debates, the profile that could be considered as adequate to teach the Ethics Workshop, was specified within the questionnaire itself as having a degree in Philosophy, Sociology, Psychology or Law. Although it must be clear that having any of the mentioned degrees does not make a professor completely prepared to teach ethics, if he can't relate the ethic fundamental concepts to the issues related to the engineering program which his students are being trained in. However, the intention on these questions is to learn about the number of professors who don't have any training at all, regarding ethics.

After receiving the answers and determining the total number of professors who taught the Ethics Workshop, the percentage of teachers with an adequate profile was calculated. Subsequently, out of the total number of teachers who do not have an adequate profile, the percentage of them who have been trained was calculated, and the results are as follows.

RESULTS AND DISCUSSION

The four items of the questionnaire where the following:

1. How many teachers in total taught the Ethics Workshop in the periods January-June and August-December 2018 at your Institute? (¿Cuántos docentes en total impartieron la asignatura Taller de Ética en los periodos Enero-Junio y Agosto-Diciembre 2018 en su Instituto?)
2. Of the total teachers who taught the Ethics Workshop in the periods January-June and August-December 2018, how many teachers belong to the Department of Economic-Administrative Sciences? (Del total de docentes que impartieron la asignatura Taller de Ética en los periodos Enero-Junio y Agosto-Diciembre 2018 ¿Cuántos docentes pertenecen al Departamento de Ciencias Económico-Administrativas?)
3. Of the total teachers who taught the Ethics Workshop in the periods January-June and August-December 2018, how many have a Bachelor's degree in Philosophy, Sociology, Psychology or Law? (Del total de docentes que impartieron la asignatura Taller de Ética en los periodos Enero-Junio y Agosto-Diciembre 2018 ¿Cuántos cuentan con una Licenciatura en Filosofía, Sociología, Psicología o Derecho?)

4. Of the total number of teachers who taught the Ethics Workshop subject in the periods January-June and August-December 2018 and who do not have any of the degrees mentioned in the previous question, how many have received any training to teach the Ethics Workshop subject? (Del total de docentes que impartieron la asignatura Taller de Ética en los periodos Enero-Junio y Agosto-Diciembre 2018 y que no cuentan con alguna de las licenciaturas mencionadas en la pregunta anterior ¿Cuántos han recibido alguna capacitación para impartir la asignatura Taller de Ética?).

The results obtained are shown on *Table 1*:

Table 1. Results obtained per question and percentage value

Question	Total amount	Percentage
1.- How many teachers in total taught the Ethics Workshop in the periods January-June and August-December 2018 at your Institute?	289	100%
2.- Of the total teachers who taught the Ethics Workshop in the periods January-June and August-December 2018, how many teachers belong to the Department of Economic-Administrative Sciences?	255	78%
3.- Of the total teachers who taught the Ethics Workshop in the periods January-June and August-December 2018, how many have a Bachelor's degree in Philosophy, Sociology, Psychology or Law?	103	36%
4.- Of the total number of teachers who taught the Ethics Workshop subject in the periods January-June and August-December 2018 and who do not have any of the degrees mentioned in the previous question, how many have received any training to teach the Ethics Workshop subject?	93	32%

Source: Own data.

About question 2, it needs to be clarified that the organizational structure of the TecNM Institutes does not include an academic department specifically of Humanities or Philosophy, given that 92% of its undergraduate programs belong to the area of engineering, and the other 8% belong to Economic-Administrative Sciences. This is the reason why the professors that teach the Ethics Workshop subject, are assigned from this Department, which will be referred to as EAS Department henceforth. That been said, the relevance of question 2 is that not all the professors that teach this subject belong to the EAS Department, but only 255 do, as shown in *Figure 2*:

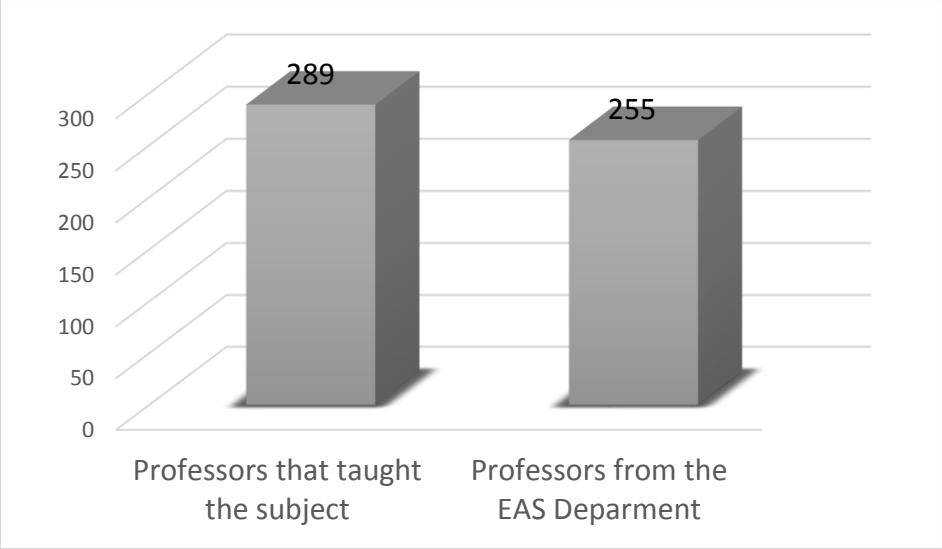

Figure 1. Teachers who taught the subject and that belong to the EAS Department.
Source: Own data.

So, only 78% of the professors who taught the Ethics Workshop subject, belong to the EAS Department, which means that, the other 31 professors who taught this subject, which represent the other 22%, not only do they not have an adequate profile regarding ethics, but they have a STEM related profile. About this situation, it is important to be very clear: having professors with a STEM or any other profile not related to ethics, teaching the Ethics Workshop is not wrong in itself, provided they are properly trained. But before doing a deeper analysis about this, another important fact must be reviewed.

According to questions 2 and 3, professors who do belong to the EAS Department, and don't have an ethics related profile, are shown in *Figure 3*:

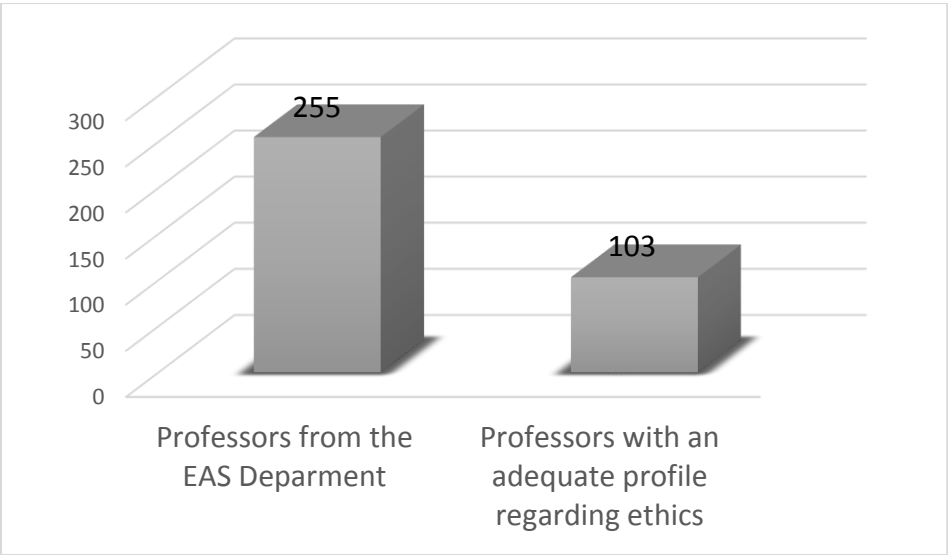

Figure 2. Professors from the EAS Department with an adequate profile.
Source: Own data.

This equals to only 40% of the teachers that belong to the EAS Department, which means that the 152 professors who represent the other 60% have an economic-administrative profile. Again this in itself is not necessary wrong. But in a more thorough analysis, it must be understood that, in order to implement any of the strategies that integrate ethics into the training of higher education students, including teaching a mandatory ethics subject, the teachers who carry out these strategies, must be professionals who fully understand the relationship between ethical science and the field of knowledge of the educational program in which the ethical aspect is to be integrated.

So, just as professors with a profile related to ethics need to understand the professional practice of the engineering program of their students, for which they have to be trained; professors with a STEM or an economic-administrative profile, can become the ideal professors for this subject, if they are trained in the ethics field of knowledge, and become capable of relating it to the professional practice of the engineering program of their students.

Just as it's happening in other universities around the world, TecNM must also advance into breaking and overcoming the false dichotomy, so entrenched and unnecessary, between the scientific-technological and the humanistic education (Usategui & Del Valle, 2010). In fact, there are documented cases in which, after being trained in ethics, teachers with more technical profiles have created groups such as the Group of Innovation in Education in Values in Scientific Technical Studies, in which they work on the development of the proper moral values of civic ethics in their respective subjects, such as statistics, electronics, drawing, engineering projects, hydraulics, among others (Félix, 2013).

So, not only can professors with profiles not related to ethics teach the Ethics Workshop subject, but they should be preferred, once they are trained in the ethics field of knowledge, over professors with an adequate profile related to ethics, but with no sufficient knowledge of the professional program in which their students are being trained.

But the most critical data revealed by the survey, has to do with the number of professors that have been trained to teach the Ethics Workshop. As question 4 was posed, it seems implicit that teachers who have any of the ethics-related profiles are properly trained to teach the Ethics Workshop, but as it has already been clarified, having an ethics-related profile is not precisely enough to be considered well prepared to impart said subject.

For the purpose of assigning teachers who are going to teach this subject, teachers who have an ethics-related profile should be preferred over those who don't have it, if none of them have been trained. Therefore, it becomes relevant to compare the total of professors that taught the Ethics Workshop, with the number of professors that have been prepared somehow to teach the subject, either because of their profile or because of some training, as questions 3 and 4 refer to.

The ideal would be that the totals of questions 3 and 4 would add up to the total in question 1, but unfortunately this is not the case, as it can be seen more clearly in figure 1, where the total number of professors that taught the Ethics Workshop subject, and the total number of professors that either have an adequate profile or that have been trained to teach the Ethics Workshop subject, are compared:

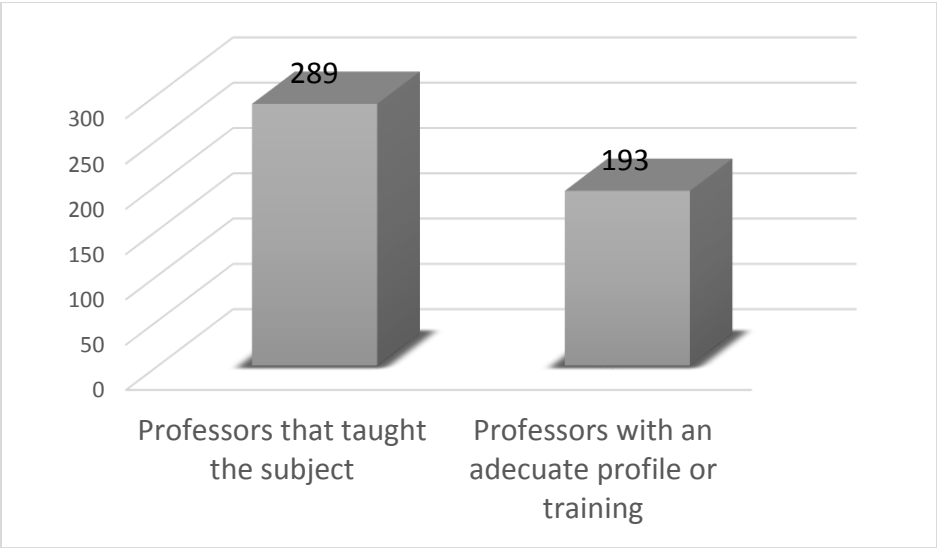

Figure 3. Number of professors with an adequate profile or training.
Source: Own data.

This means that only 68% of the professors that teach this subject are somehow prepared for it, which is clearly a problem that needs to be addressed. Having someone teaching something in which he or she is not trained, is unacceptable at any educational level, but it becomes more serious in higher education, where the level of specialization should be higher.

In addition to this, the teaching of ethics is particularly more complex, and requires a lot of sensitivity and mastery of the subject to handle participations in an appropriate manner, as well as being careful not to impose the teacher's own opinion, because otherwise, it becomes nothing more than an indoctrination (Bonilla, 2009). And since even while having an adequate profile or training, there may be room for an analysis regarding the content and methodology used to teach the Ethics Workshop, if 32% of the professors who teach this subject are not trained or have an adequate profile, it can be concluded without doubt, that the teaching of ethics at the TecNM is not being carried out properly.

As it was said earlier, apart from been capable of teaching ethics fundamental concepts, the professor of the Ethics Workshop must also be able to relate them with the field of knowledge and the common moral issues that arise in the professional practice of the engineering program that his students are studding. For teachers who have an adequate profile as defined in question 3, this means that they require even more training apart from their degree, in order to be considered well prepared to teach this subject to engineering undergraduate students.

To summarize, in *Figure 4* is the number of professors who taught the Ethics Workshop and their profiles:

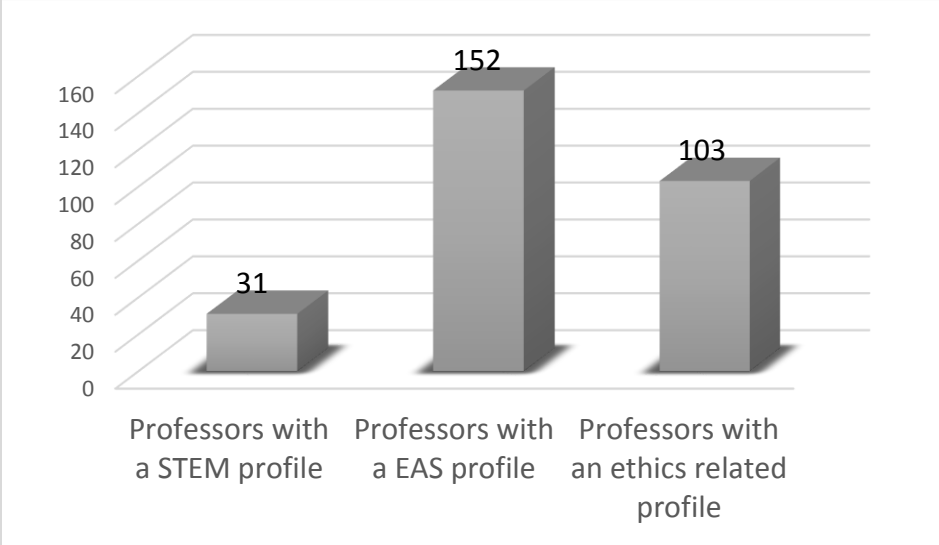

Figure 4. Profiles of the professors who taught the Ethics Workshop.
Source: Own data.

This means that 183 professors that taught the subject, don't have a ethics related profile. And out of those, *Figure 5* shows how many received some ethics related training:

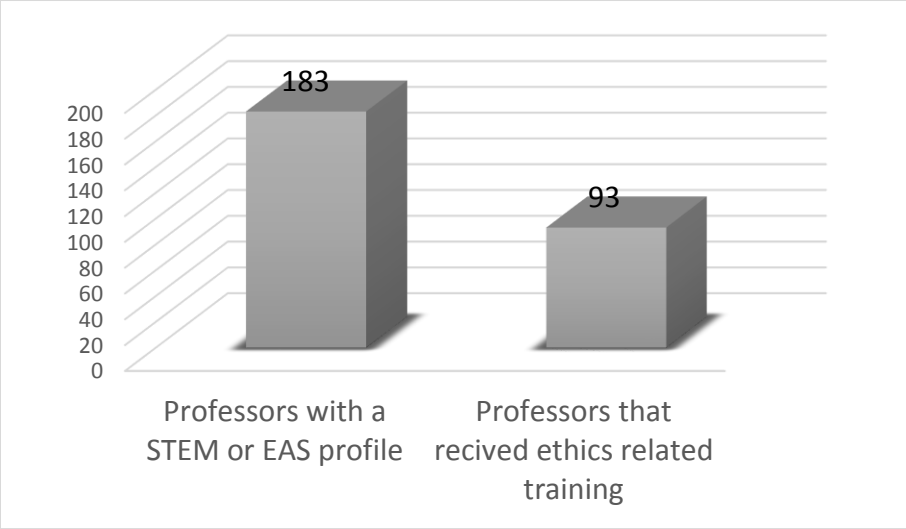

Figure 5. Professors with a STEM or EAS profile that recived ethics related training.
Source: Own data.

This means that a total of 90 professors with a STEM or EAS profile taught the Ethics Workshop subject, without having received any ethics related training, which is clearly a unacceptable situation.

Another thing that should be noted, is that having a STEM profile does not mean that these professors are familiar with the engineering program in which they thought the Ethics Workshop, because they may belong to the Basic Sciences Department. So, there is another subgroup of professors, out of the 90 professors just mentioned, who taught the Ethics Workshop subject; don't have an ethics related profile,

haven't received any ethics related training; but also, don't have the engineering profile that their students are studying. In which case, they would need to be trained in ethics, and trained also on the area of knowledge of the engineering programs in which they are needed to teach the Ethics Workshop. Assigning teachers who are in this circumstance, should be enough to put in clear perspective the seriousness of the problem that permeates TecNM institutes.

In a different matter, regarding the other 5 items that asked for more general information in order to provide some complementary statistical data, some of this information helps providing a deeper context about the results of this study. Given that TecNM institutes are located in each and every one of the states that make up the Mexican Republic, an interesting factor is the geographical distribution of the institutes that answered the survey, as the results could be the sole problem of a few states or a specific region. It should be clarified that a common way to classify the 32 states that conform Mexico, is to divide them into three zones: north, center and south. This classification of zones, allows to group the states that share economic and socio-cultural contexts in general.

This being said, after receiving the survey responses, it was found that, out of the 43 institutes that answered the survey, 11 belong to states in the northern zone, 20 belong to states in the central zone and 12 institutes belong to states in the southern zone. If we consider the percentage that these amounts represent of the total number of institutes that responded, and compare it with the percentage that represents the total number of states that make up each region, we can see that the geographical distribution of the institutes that responded is quite homogeneous, as shown in *Table 2*:

Table 2. Comparison between institute location by zone, and the number of states per zone

Zone	Institutes that responded	Percentage value	States in each zone	Percentage value
Northern Zone	11	26%	11	34%
Central Zone	20	47%	12	38%
Southern Zone	12	28%	9	28%

Source: Own data.

In other words, the distribution by areas of the total number of institutes that responded varies only by 6% with respect to the percentages of states that make up each region. Therefore, it can be said that there was no regional bias in the responses obtained, and that the results represent a situation that is common in institutes of TecNM throughout the country.

It is also worth mentioning that the total number of states, to which the 43 institutes that responded to the survey belong to, is 19, which represents 59% of the 32 states that conform Mexico. Furthermore, with the exception of the southern zone, responses were received from more than half of the states that make up each zone, as it can be seen in *Table 3*:

Table 3. Percentage of states from which answers where received and number of states per zone

Zone	States in each zone	States from which answers were received	Percentage value
Northern Zone	11	7	64%
Central Zone	12	8	67%
Southern Zone	9	4	44%
Totals	32	19	59%

Source: Own data.

This is also a very favorable distribution since the total number of states from which answers where received, represents more than half of the states in the country.

All the geographical distribution is best represented in *Figure 6*, in which we can see the number of institutes that answered from each state, and it should be reiterated that no sampling technique was used in this research work.

Figure 6. Number of institutes that answered per state and zone.

CONCLUSIONS

The general objective of this research was fulfilled, by offering a diagnosis about the way in which the strategy of teaching a compulsory ethics course for all students of engineering undergraduate programs, is being implemented, at the institutes of the TecNM. And given the importance of the reasons for which ethics are sought to be incorporated into engineering undergraduate programs, the relevance of this diagnosis is crucial, since it shows that it is necessary to urgently review the profiles and, above all, the training of the professors who teach the Ethics Workshop at the TecNM Institutes.

Since hiring professors and accommodating the ones that are already hired, is not a very dynamic process in Mexican public education, including the TecNM Institutes, the most efficient strategy to revert the found problem, would be to implement a nationwide training program for those professors interested in teaching this subject, that have not received any training regarding ethics science. This strategy is consistent with the fact that ethics is a field of knowledge that is intrinsically related to every other field of knowledge. Professors who teach the Ethics Workshop for undergraduate engineering students, need to have solid foundation on ethics science, which can be provided by an appropriate training course, and knowledge about the professional practice of the engineering programs in which they will teach this subject.

Also, another training program required should be aimed at teachers with a profile related to ethics, in which they can get familiarized not just with the field of knowledge of the engineering programs taught at their institutes, but with the moral problems that commonly arise on their professional practice. Examples and cases of study could be compiled in some sort of bank of topics to be discussed for the Ethics Workshop, sorted by engineering program, so that they become available for all the professors who teach the subject at any TecNM institute.

Following research efforts should focus on how to train teachers in regard to ethics, considering both content and methodology. Especially considering that there are already a good number of research studies that focus on this topic. Needless to say, when done in the right way, this type of training triggers a strong interest in ethics, that can have an impact even on the teaching of the other technical subjects of engineering programs, in which although they are not the central theme, surely the ethical reflections related to these technical subjects will be reinforced. In addition, higher education institutions will also see benefits related to the compliance and professionalism of their professors, because of them being aware of ethical reflections, which, if they find a way to relate them to the future professional practice of their students, they will easily relate them as well to their own professional practice as professors.

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