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Propensity for the transition towards Education 5.0 in the training of engineers. Case Study in Mexico

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***Abstract*– The industry is rapidly changing from a 4.0 phase to a 5.0 phase, focusing on developing people who form a 5.0 society. Generating this type of society implies preparing institutions that train professionals with a 5.0 Education. The objective of this research is to determine the level of propensity of teachers and students of the Technological Institute of Higher Studies of Cuautitlán Izcalli, to use emerging technological tools as well as collaborative work in the appropriate context to implement Education 5.0 in the academic plans for the training of engineers that it currently provides, and with an orientation to comply with the pedagogical bases of the New Mexican School. The results show that teachers do use digital platforms within their teaching process and that students do know how to use these technologies, although they do not use them extensively in their learning process. The proposal is the inclusion of a didactic that involves dialectical teaching-learning techniques, situated in their community, generating critical thinking and the necessary skills to work collaboratively.**

***Keywords--** Engineering education, teaching standards, academic standards, learning processes.*

I. Introduction

Undeniably, education plays an important role in analyzing economic growth within a society [1] [2]. Higher education generates more critical, responsible, and participative citizens, motivates innovation, creativity, and technological development that drives increased productivity, and can also be an important driver of mobility and social equality.

As industry continues to evolve and grow constantly [3], there is a need for trained people who can integrate the use of technological tools and platforms within a society that quickly assimilates changes [4]. In this context, as drivers of knowledge, universities play a crucial role in building the innovation process and projecting change [5]. The role of those who train engineers must be focused on the needs of the industry [6]. There is a constant concern that engineering training institutions provide suitable people who help companies solve their problems, allow them to survive in the great technological, digital, and innovation changes, and achieve growth that generates societies focused on people trained with sustainable awareness and aimed at well-being.

Industry 4.0 is currently used to refer to the digital transformation of manufacturing industries that focuses on automation, interconnectivity, and real-time process optimization using enabling digital technologies [7]. It emphasizes the use of technology, including technology related to the Internet of Things, artificial intelligence, and Big Data analysis [8]. Engineering training plans are beginning to reflect this knowledge in their graduates. However, academics are driving new trends in their preparation, both at the industry level and in education, by contextualizing it in a 5.0 environment [9], [10].

Industry 5.0 highlights the need to rethink existing working methods and approaches to innovation and focus on developing human-oriented solutions and social innovation [11]. Society 5.0 aims to place humans in the middle of innovation, exploiting the impact of technology and the results of Industry 4.0 with technological integration to improve quality of life, social responsibility, and sustainability. It resembles a link between the changes in technology, digital, and information flow areas, and focuses its activities on the sustainable development concept of societies [12]. The connection between both scenarios is Education 5.0, a student-centered approach, with students as protagonists rather than passive listeners, with more collaborative, individualized classes focused on the development of hard and soft skills, using new technologies through devices, infrastructure, and platforms, tools that must support learning [13].

II. Background

A. Evolution of Industry 5.0.

The early 19th century saw the beginning of the Industrial Revolution, through which agrarian society moved towards industrialization and urbanization, with resources such as coal, water, and steam being predominantly used to power large steam engines used in the textile and manufacturing industries, resulting in a significant migration of people from the countryside to the city [14]. It is believed to have begun in Britain before spreading to the rest of Europe and America [15]. The late 19th and early 20th centuries saw the second Industrial Revolution, characterized by widespread science-based inventions such as the mechanization of agriculture, textile industries, railways, machinery, internal combustion engines, electric power, and iron and steel production. Vaclav Smil [16] called the period between 1867 and 1914 the "Age

of Synergy", during which the foundations for the advances of the 20th century were laid. However, the downside of both industrial revolutions was associated with poor and dangerous working conditions that led to the formation of unions and regulations in factories to protect workers.

The third industrial revolution began in the 1950s with the invention of transistors and microprocessors, which paved the way for automated production supported by various electronic devices. Digital sensors and computers became a part of workshops. Although working conditions improved greatly during this period, labor exploitation continued, cities became overpopulated, and widespread pollution and environmental degradation became common in large cities worldwide [17]. The fourth industrial revolution used the technology of the previous stage to generate data. The term Industry 4.0 was coined by German professor Wolfgang Wahlster in 2011 at the Hannover Fair. The digital transformation of manufacturing industries focuses on automation, interconnectivity, and real-time process optimization to communicate and control each other [7]. In other words, it can be called the informatization of manufacturing, where advanced digital technologies are married with machines and industrial processes. The interconnection of these technologies in the manufacturing setup is to achieve operational efficiency, productivity, and automation to the greatest extent possible. This, in turn, creates a manufacturing ecosystem that is smart, connected, and data-driven [18]. If Industry 4.0 is about digitally connecting machines to enable a seamless flow of data and as much optimization as possible, Industry 5.0 is seen to put more emphasis on a human view with cognitive systems that provide more suitable conditions for the person, while also focusing on sustainable manufacturing [19].

B. Evolution of Society 5.0 and Education 5.0.

Society has evolved in part in line with the development of the Industrial Revolution. Nomadic hunters and gatherers are considered Society 1.0. The rise of agriculture and settled communities gave way to Society 2.0. With the arrival of this type of society, the Industrial Revolution took place, in which machines and mass production were introduced, giving way to Society 3.0. Society 4.0 is the era of information and the power of connectivity, characterized by the integration of advanced technologies such as artificial intelligence, big data, robotics, and the Internet of Things. We are moving towards Society 5.0, a vision that seeks to harmoniously integrate advanced technologies, known as frontier technologies, with human well-being, promoting equality, social inclusion, sustainability, and citizen participation. It is about harnessing the potential of technology to solve current challenges [4].

Similarly, education has gone through several stages, each marked by significant technological advances and changes in the way knowledge is delivered and received. Education 1.0 was characterized by a traditional, one-way approach, focused on the transmission of information from teacher to student. This model, predominant for centuries, limited the interaction and personalization of learning. Education 2.0 introduced basic technologies that allowed for greater interaction and collaboration between students and teachers. The use of the internet and basic digital tools began to change the dynamics of the classroom, facilitating access to a wide range of educational resources. Education 3.0 brought with it greater integration of more advanced technologies, including e-learning platforms and online collaborative tools. This period was characterized by a more student-centered approach, where students could access personalized educational content and participate in more interactive learning environments. Education 4.0 delved even further into digitalization, introducing elements such as artificial intelligence (AI) and machine learning into the educational process. These technologies have enabled unprecedented personalization of learning, adapting content to each student's individual needs and preferences.

Today, we are living in the stage of Education 5.0, which combines all these technological advances with a holistic approach that values both technical and soft skills. Artificial intelligence and advanced digital tools play a crucial role in creating highly personalized and efficient learning environments [13]. During this time, learners could engage with tailored educational content and immerse themselves in more interactive learning environments.

In this context, universities, especially those that train engineers, must be geared toward adapting to these conditions to provide super-intelligent societies with knowledge and skills that adapt, on the one hand, to production systems, and on the other, that these adapt to generating well-being for individuals and society.

Carayanis and Morawska-Jancelewicz [6] propose a socially and digitally engaged university model that embraces the new roles of the university in the innovative ecosystem. The model is based on key foundations and assumptions for becoming more responsible and socially engaged universities; therefore, it is necessary to establish new power relations within the university, between science and its industrial application, and with society. This means, for example, promoting and recognizing the social activities of students and scientific and administrative staff, with their public engagement. It also requires building an organizational culture focused on cooperation, mutual learning, and the establishment of interdisciplinary working groups. In addition, it is necessary to provide a system of continuing education related to digital and sustainable transitions. Furthermore, if the university wants to practice what it preaches, it must also promote a culture of equality and anti-discrimination. Externally, it means that the university builds relationships with stakeholders based on the new paradigm of knowledge democratization, in which knowledge is developed as part of collaborative construction, i.e., because of the combination of academic and practical knowledge generated by various stakeholders and participants in the innovation process. Universities need more adaptability and flexibility.

III. THEORETICAL FRAMEWORK

A. Features of Education 5.0.

The COVID-19 pandemic caused social isolation, but this made life even more digital. For example, online payments and procedures, online classes, and distance education have gone from being a trend to becoming a reality, and everyone has had to adapt to them. However, more than technological tools, the pandemic highlighted the need to prepare human beings for adversity and create emotionally intelligent people who know how to use digital transformation as a tool for social transformation [20].

Education 5.0 is the use of new technologies to offer a more humane education, focused on the socio-emotional development of students and the generation of solutions that improve life in society. It is considered an evolution of person-centered pedagogy, with a high degree of interconnection and the ability to make strategic use of technology. This education seeks to integrate technology with a humanistic approach and develop skills, competencies, and values for society 5.0. Its main characteristics are:

Using technology for more humane teaching. The aim is to use technology to adapt to students' individual needs. This involves using digital tools to offer face-to-face education and high-quality and flexible distance education.

Promoting holistic student development. This approach to education seeks to promote the comprehensive development of the student, considering academic, emotional, aspirational, and social aspects.

Focus on sustainability. We seek to increase the sense of social and environmental responsibility, promoting practices that generate minimal environmental impact, with greater health and safety.

Developing a global citizenship mindset. This educational approach seeks to prepare individuals with the skills, mindset, and adaptability needed to thrive in a connected and ever-evolving world.

Promotion of multidisciplinary projects with political and social relevance. Critical thinking, creativity, and interdisciplinary problem-solving skills are encouraged.

B. New Mexican School.

The New Mexican School (NEM for its initials in Spanish) is an educational proposal promoted by the Secretariat of Public Education (SEP) of Mexico to transform the educational system and provide quality, inclusive, and equitable education for all students. It seeks to build a fair and quality education in Mexico, where all students have equal opportunities to develop their skills and potential [21].

The NEM generates applied teaching in four distinct areas: dialogic techniques and methodologies, situated teaching, critical awareness, and collaborative learning. They seek to promote the integral development of students through competency-based learning and the use of digital tools, strengthening professors' training in teaching technologies based on emerging technologies, and applying it to the community context.

IV. Methodology

The methodology used follows the scientific method and consists of the following steps:

- Problem definition.
- Formulation of the hypothesis.
- Description of current conditions.
- Design of experiment.
- Analysis and discussion of the results.
- Verification and validation of the hypothesis.

V. Applying Methodology

Problem definition. This study aims to determine the propensity of the teaching and student body to use technologies to enhance the teaching-learning processes and their adaptation to the realization of the aspirations of both actors in their aspects.

Formulation of the hypothesis. There are sufficient technological conditions and human resources to implement an Education 5.0 model in the academic training plans for engineers currently provided by the National Institute of Technology of Mexico/TES Cuautitlán Izcalli (TESCI for its initials in Spanish).

Description of current conditions. TESCI is a decentralized public organization of the State of Mexico Government, located 30 km northwest of Mexico City, in the Municipality of Cuautitlán Izcalli. Its vision is "To be recognized as one of the best technologically socially responsible higher education institutions, with accredited educational programs and certified processes under national and international quality standards, which guarantee the positioning of our graduates in the globalized labor market." Its mission is expressed on its website, as well as in some public consultation documents, as follows: "To comprehensively train professionals, teachers and researchers who are competitive at a national and international level, possessing a critical and analytical sense, with a humanistic vision and ethical conscience, drivers of economic, scientific, technological and cultural development, with an innovative sense, who contribute to the growth of the region, the State and the country, in a socially responsible manner within a framework of personal excellence" [22].

In 2023, the university registered 6,463 students enrolled in 8 engineering programs, one bachelor's degree program, and two graduate programs. Its infrastructure includes 10 buildings, sports areas, recreation areas, food courts, and various social spaces [23].

Design of experiment. Two surveys were designed with Likert-type items: number 1, for application to the student population, consisting of 10 questions, and number 2, for teachers, with 14 items. Both surveys are intended to measure the propensity of both students and teachers to use contemporary technologies and soft skills in the teaching-learning process. The first was applied to 326 people from the population enrolled as students within the TESCI; the second was applied to 16 teachers from engineering programs.

Regarding reliability validation, Cronbach's alpha was used, with results of 0.75 and 0.91 for students and teachers, respectively, values adequate to support confidence in the results [24].

VI. Analysis And Discussion

Survey 1, applied to the student sample of 326 people, two blocks are identified; the first block focuses on measuring the frequency with which students perceive their interaction with technologies in their learning process. The second block assesses their propensity to use these technologies to enhance their skills. Table I shows the reagents of the first block, measured on the Likert scale, where 1 means "never used", changing to 5, which means "always used".

TABLE I
THE FIRST BLOCK OF SURVEY 1

Item	Question	1	2	3	4	5
1	How often do you find that the assessments you take in class accurately reflect what you have learned?					
2	How often do you use other learning spaces at the institution, such as the library or the online classroom, to complement your studies?					
3	How often do you use emerging technologies (such as artificial intelligence or augmented reality) to support your learning activities?					
4	How often do you use simulators or specialized software to solve practical problems in your subjects?					
5	How often do activities on digital platforms for your subjects include interactive exercises or immediate feedback?					

The results are presented using bar graphs, considering the rating scale on the x-axis and the frequencies in percentage on the y-axis. These show that technologies are not usually used to support student learning. In 80% of these questions, option 3 is the middle term, highlighting question 2, which shows that the student population rarely uses the digital resources available to the Institution, as seen in Figure 1.

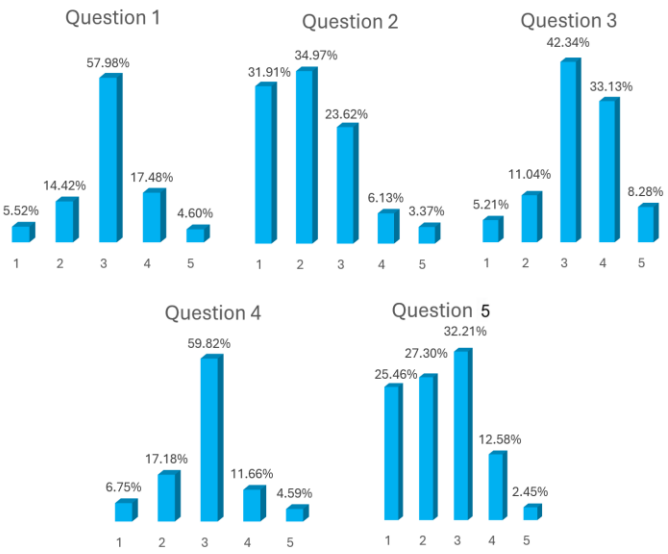

Fig. 1 Graphs with the response percentages of the first survey block 1.

Block 2 measures students' satisfaction and usefulness with the use of technologies in their learning process. Response options range from 1, meaning very little, to 5, meaning too much use. The items and questions are presented in Table II.

TABLE II
THE SECOND BLOCK OF SURVEY 1

Item	Question	1	2	3	4	5
6	How useful is group project learning for you in understanding the content of your classes?					
7	How satisfied are you with the support you receive from teachers to resolve doubts or difficulties in your studies?					
8	How satisfied are you with access to online platforms and digital tools that complement your learning?					
9	To what extent do you prefer active learning strategies (for example, practical activities, projects, or group dynamics) over lectures?					
10	To what extent do you think using emerging technologies, such as artificial intelligence or augmented reality, improves your learning experience?					

The graphs in Figure 2 illustrate a range of responses. In question 6, which deals with the usefulness of group projects in learning, over 45% of respondents expressed satisfaction with teacher feedback as well as the application of online platforms as teaching strategies. Conversely, questions 7 and 8 revealed a neutral stance from nearly half of those surveyed. For items 9 and 10, which assess preferences for more active classes that incorporate emerging technologies, acceptance rates are notably high at 72.9% and 82.82%, respectively.

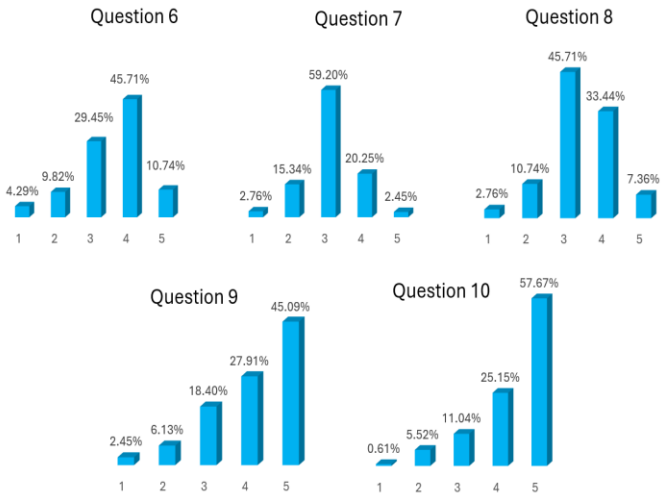

Fig. 2 Graphs with the response percentages of the first survey block 2.

A survey with 14 questions was also administered to 16 professors on the application of technologies in the teaching process; it also consists of two blocks. The first one focuses on characterizing the frequency with which technologies are used in said process, as presented in Table III.

TABLE III
THE FIRST BLOCK OF SURVEY 2

Item	Question	1	2	3	4	5
1	How often do you use digital platforms such as Microsoft Teams, Google Classroom, or like manage and assess student activities?					
2	How often do you recommend online resources, such as tutorials, academic articles, or specialized forums, to complement student learning?					
3	How often do you incorporate activities that promote soft skills, such as leadership, critical and ethical thinking, in your students?					
4	How often do you organize activities in which students use emerging technologies such as simulators, software, or artificial intelligence to solve real problems?					
5	Do you often use collaborative activities in which students work in teams to achieve common goals?					
6	Do you frequently use communication platforms, such as forums or chats, to encourage interaction between students outside the classroom?					
7	How often do you use resources outside the classroom, such as laboratories, libraries, or telematics spaces, to enrich student learning?					
8	How often do you include dynamic activities, such as games or gamification techniques (Kahoot, Quiz), to reinforce concepts or skills?					
9	How often do you seek training or resources to stay up to date on relevant technological trends in education?					

Figure 3 shows the results of the first five questions. These show that teachers constantly use digital tools in the teaching process, either as a form of interaction (questions 1 and 2), for their soft skills (question 3), or for teamwork applied to real problems (questions 4 and 5).

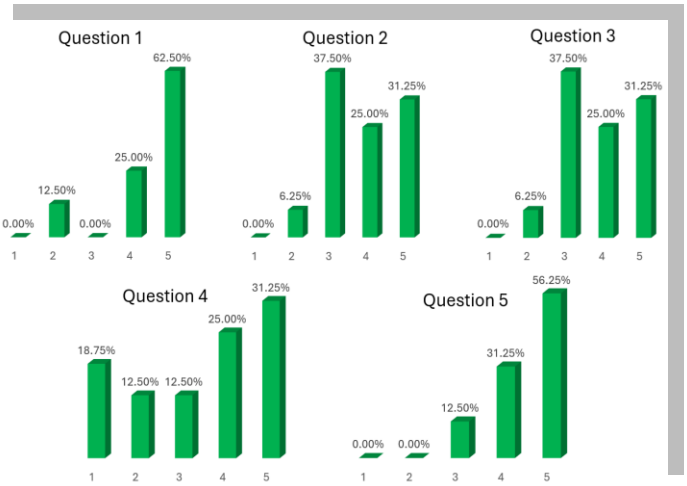

Fig. 3 Graphs with the response percentages of the second survey block 1, question numbers 1 to 5.

Questions 6, 7, and 9 indicate an orientation towards forums, digital libraries, and constant updating. However, as Figure 4 shows, it cannot be established that gaming is a widely used tool in question 8.

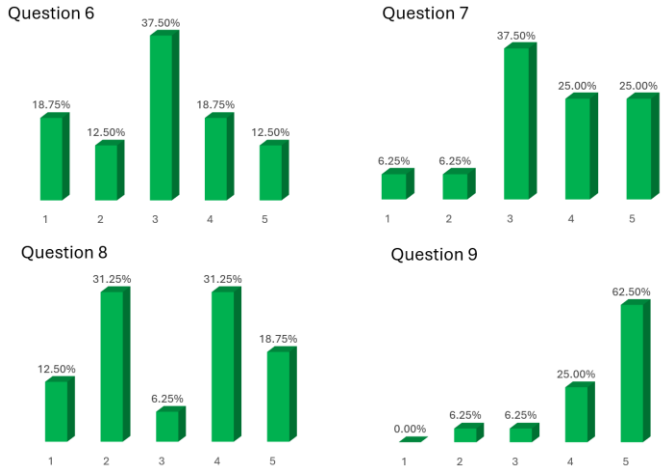

Fig. 4 Graphs with the response percentages of the second survey block 1, question numbers 6 to 9.

The second section of this survey measured various aspects: the promotion of autonomy, ethical reflection, the coverage of acquired skills, the impact of projects on knowledge acquisition, and the use of emerging technologies in teaching processes. These topics correspond to questions 10, 11, 12, 13, 14, and 15. The specific wording of each question is presented in Table IV. Respondents rated their experiences on a scale from 1 to 5, where 1 indicates "nothing or very little" and 5 represents "a lot."

TABLE IV
THE SECOND BLOCK OF SURVEY 2

Item	Question	1	2	3	4	5
10	To what extent do you encourage autonomy in your students' learning through activities that promote research and self-study?					
11	To what extent do you promote ethical reflection on the impacts of engineering on society in your classes?					
12	To what extent do you consider that your class's assessments reflect technical and human skills, such as communication, leadership, or teamwork?					
13	Do you implement projects or activities that include emerging technologies as part of practical learning in your classes?					
14	How familiar are you with emerging technologies, to apply them in your teaching?					

The results indicate that when professors encourage autonomy in student work, it is reflected in 81.25% of cases. Furthermore, ethics is promoted in about 93.75% of instances. Classroom evaluations are viewed as a reflection of skill acquisition by 81.25% of respondents. The promotion of projects utilizing emerging technologies stands at 56.25%,

while teacher familiarity with these technologies is 75%. These high percentages highlight various strengths in the teaching process, as illustrated in Figure 5.

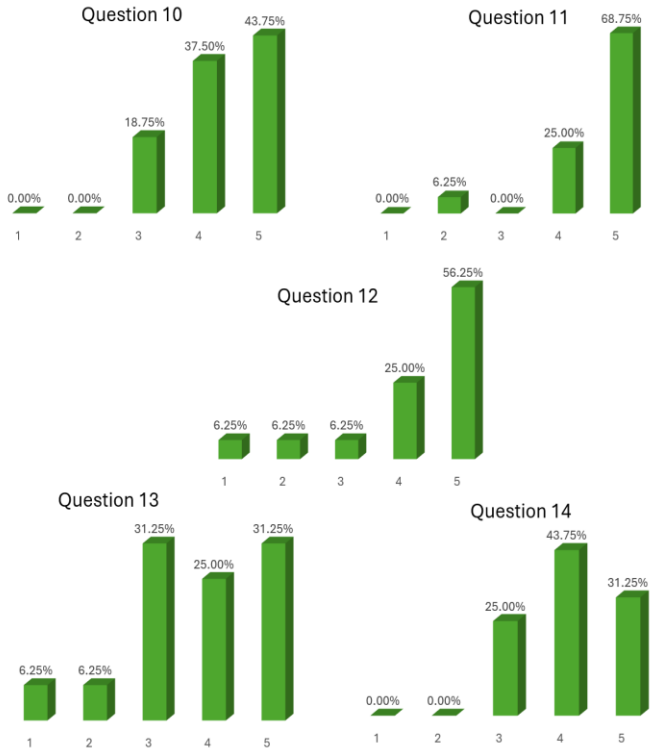

Fig. 5 Graphs with the response percentages of the second survey block 2.

VII. Hypothesis Validation

The results show that there is sufficient evidence to demonstrate that it is possible to integrate a model referenced in Education 5.0, due to the following factors:

- Students tend to use information technologies, but their use in their teaching practices is not very common, although they are interested in applying them.
- Professors apply digital tools in their teaching process and tend to update themselves in their subjects.

VIII. Conclusions and Recommendations

Since it has been found that teachers do use digital platforms within their teaching process and that students do know how to use these technologies, although they do not use them extensively in their learning process, it is possible to create an Education 5.0 model focused on the transformation of the roles of both teachers and students, which is why the inclusion of the following four aspects is proposed:

Teachers can establish dialogic techniques based on dialogue and respectful communication in the classroom, such as discussion forums, the trigger question, and the six thinking hats, among others, to create student participation.

Establishment of situated techniques and methodologies, such as case studies, project-based learning, or gamification applied to specific cases, which allow students to visualize cases of application of their learning in real environments.

Creating critical awareness in the student through techniques such as the critical use of technology, simulation of power situations, or challenging stereotypes to create a vision that contrasts both positive and negative effects in decision making.

Using collaborative techniques, either in person or by technological platforms, where some system simulations can be applied, the Delphi method, collaborative creation of models, among others.

The generation of students who adapt quickly to their work environments, with an extensive use of technologies and with the ability to relate to people from different cultures, must be associated with models that can be reproduced by university professors, in a systemic way and with the ability to quickly adapt to change, is the purpose of this new model compatible with the New Mexican School (NEM). But it is important to recognize that change must contain elements of a system that integrates new relationships in the teaching-learning processes, with teachers who are more drivers of new practices of knowledge acquisition and generation, with skills that allow the creation of technologically well-prepared students, skillfully instructed to work in multidisciplinary teams and with a focus on solving current problems in their community.

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