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Scientific articles

El saber hacer en ingeniería en la era virtual: estudio de caso de una profesión

Engineering know-how in the virtual era: case study of a profession

Know-how de engenharia na era virtual: estudo de caso de uma profissão

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Resumen

El uso efectivo de las TIC en los procesos de enseñanza-aprendizaje sigue siendo objeto de investigación y debate, ya que se requiere de estrategias didácticas adecuadas para lograr una formación integral y transdisciplinaria basada en competencias que incorpore conocimientos teóricos y prácticos. Este estudio tuvo como objetivo la identificación y eficacia de estrategias didácticas orientadas al "saber hacer" en cursos que son eminentemente virtuales. Se centró en revisar qué tan eficiente son los planteamientos didácticos para favorecer aprendizajes significativos en carreras científico-prácticas, a través del análisis de las percepciones de alumnos y docentes respecto del uso de herramientas tecnológicas en un programa educativo de ingeniería de nivel Licenciatura que opera en modalidad virtual. La metodología de investigación empleada fue mixta, incorpora herramientas tanto cualitativas como cuantitativas; se realizó una investigación documental mediante análisis de contenido que englobó los programas de asignatura, posteriormente se aplicó una encuesta semiestructurada a estudiantes y profesores con el fin de encontrar correspondencias entre los análisis de las asignaturas y la forma en que lo asumen alumnos y docentes. Se concluye que el uso de determinadas estrategias didácticas y el acompañamiento del profesor son

fundamentales para alcanzar aprendizajes significativos; el apoyo en herramientas tecnológicas contribuye al logro de los elementos descritos en el perfil de egreso, sobre todo en los saberes teóricos, no obstante, en lo que compete a aprendizajes "prácticos" existen limitaciones señaladas por los estudiantes que obstaculizan sobre todo la experiencia directa y por consiguiente el desarrollo de habilidades y destrezas.

Palabras clave: educación superior, modalidad virtual, multidisciplina, estrategias didácticas, aprendizaje.

Abstract

The effective use of ICT in teaching-learning processes continues to be the subject of research and debate, as adequate didactic strategies are required to achieve a comprehensive and transdisciplinary training based on competencies that incorporate theoretical and practical knowledge. This study aimed to identify and evaluate the effectiveness of didactic strategies oriented towards "know-how" in courses that are eminently virtual. It focused on reviewing how efficient the didactic approaches are to promote meaningful learning in scientific-practical careers, through the analysis of the perceptions of students and teachers regarding the use of technological tools in an undergraduate engineering program that operates in a virtual modality. The research methodology used was mixed, incorporating both qualitative and quantitative tools; documentary research was carried out through content analysis that included the subject programs, subsequently a semi-structured survey was applied to students and teachers in order to find correspondences between the analysis of the subjects and the way in which they are assumed by students and teachers. It is concluded that the use of certain didactic strategies and the accompaniment of the teacher are fundamental to achieve significant learning; the support in technological tools contributes to the achievement of the elements described in the graduate profile, especially in theoretical knowledge, however, as far as "practical" learning is concerned, there are limitations pointed out by the students that hinder above all direct experience and consequently the development of skills and abilities.

Keywords: higher education, virtual education, multidisciplinary, teaching strategies, learning.

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Resumo

A utilização eficaz das TIC nos processos de ensino-aprendizagem continua a ser objeto de investigação e debate, uma vez que são necessárias estratégias de ensino adequadas para alcançar uma formação integral e transdisciplinar baseada em competências que incorporem conhecimentos teóricos e práticos. O objetivo deste estudo foi identificar e efetivar estratégias de ensino voltadas ao "saber fazer" em cursos eminentemente virtuais. O foco foi revisar o quão eficientes são as abordagens didáticas para promover aprendizagens significativas nas carreiras científico-práticas, por meio da análise das percepções de alunos e professores sobre o uso de ferramentas tecnológicas em um programa de ensino de engenharia em nível de bacharelado que funciona na modalidade virtual. A metodologia de pesquisa utilizada foi mista, incorporando ferramentas qualitativas e quantitativas; Foi realizada uma investigação documental através de análise de conteúdo que abrangeu os programas das disciplinas, posteriormente foi aplicado um inquérito semiestruturado a alunos e professores de forma a encontrar correspondências entre a análise das disciplinas e a forma como os alunos e professores as assumem. Conclui-se que a utilização de determinadas estratégias de ensino e o apoio do professor são essenciais para alcançar uma aprendizagem significativa; O apoio de ferramentas tecnológicas contribui para o alcance dos elementos descritos no perfil da graduação, principalmente no conhecimento teórico. Porém, quando se trata de aprendizagem "prática", há limitações apontadas pelos estudantes que dificultam especialmente a experiência direta e consequentemente a experiência. desenvolvimento de competências e habilidades.

Palavras-chave: ensino superior, modalidade virtual, multidisciplinaridade, estratégias de ensino, aprendizagem.

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Introduction

Recently, Higher Education Institutions (HEIs) have reformed their development plans, organizational schemes, as well as their policies and strategies aimed at professional training and social contribution. All these new orientations converged as a consequence of social, economic and political events, especially in the context of the SARS COVID-19 pandemic.

Universities are no exception to the changing reality in which we currently live:

> There is a debate in the social sciences about whether the truth and quality of the institutions of a given society are best known in situations of normality, of ordinary functioning, or in exceptional situations, of crisis. Perhaps both types of situations are equally conducive to knowledge, but they certainly allow us to know or reveal different things. There is a lot of potential knowledge resulting from the coronavirus pandemic (De Souza Santos, 2020, p.19).

Higher education has gained greater relevance in this context of globalization, in the so-called knowledge society and also in this framework of uncertainty that has involved profound processes of reflection and decision-making on its purposes and procedures to offer relevant professional options, to promote the generation and application of knowledge and to correspond responsibly with social needs.

Regarding these challenges, the use of non-face-to-face modalities was strengthened, which represented important changes in the educational field. At the higher education level, the rise of these modalities has rethought the teaching and learning processes. This has caused substantial changes in the way universities operate, in their structure, their teaching models and also in their connection with social sectors. This trend has gained strength with the effects of the COVID-19 pandemic, a situation that will apparently enhance this orientation towards virtuality in the coming years.

In this sense, Castañeda and Selwyn state that:

> Digital technologies offer a large number of possibilities for generating different learning environments that enhance the flexibility of the design, in terms of objectives, strategies, itineraries and learning sequences, as well as evaluation methods for the characteristics of the student, in line with personalization. The digital technologies that we have, but also past technologies, have contributed and contribute to facilitating this type of learning, and in a large number of experiences they have been used for this purpose. (2019, p. 80)

In short, there is little research that refers to the effective use of technology to promote teaching and learning processes. In this regard, authors such as Barrera and Linden (2009), Cobo and Moravec (2011), Castañeda and Swelin (2019) and Pane *et al.* (2017), maintain that there is no conclusive evidence on the appropriate use of technology to promote meaningful learning. Although research that delves into the impact of technology on teaching and learning processes has increased in recent years, it is difficult to have a general perspective of its educational impact, which keeps the field of inquiry open to learn about

actions and strategies that provide positive results, as well as those that have been counterproductive in the learning process.

The change that has taken place in recent years, specifically the transition from a model based on objectives to models based on competencies, imposed a substantial variation in the way of approaching the training of university students, moving from perspectives based exclusively on the acquisition of knowledge specific to the discipline to models based on comprehensive and transdisciplinary training.

The competency approach integrates elements that are articulated to achieve a goal, including the link with real learning contexts, in such a way that it incorporates theoretical knowledge and practical knowledge, as well as the axiological perspective. Consequently, mastery of a competency implies a plurality of intertwined actions that allow the articulation of the cognitive-theoretical dimension, called declarative knowledge; the practical dimension, performances and executions, qualified as procedural knowledge; and the value dimension where ethical and moral constructs intervene, referred to as axiological knowledge.

To clarify the above,

> Declarative knowledge is encoded verbally and therefore has an explicit and conscious character. It is usually expressed with the formula: "know that". Procedural knowledge is actively encoded and refers to the operational relationship with things in the world. Since its level of encoding is non-verbal, it is mostly implicit and therefore does not require the agent to know the executive structure. Typically, this type of knowledge is introduced using the formula "know how" (Domínguez, *et al.*, 2021, p. 20).

However, it is necessary that these two types of knowledge converge and not be seen as fragmented elements. Since one complements the other and vice versa to generate meaningful knowledge. "It must then be added that competence requires both "cognition" and "metacognition". Indeed, authentic competence is not reduced to executive capacity, but includes a certain degree of awareness of its internal organization*"* (Domínguez *et al.,* 2021).

This research is based on the idea that the use of ICT in teaching-learning processes is associated with the type of didactic strategies implemented in the different disciplinary approaches and the contexts. The objective of this study is to investigate the didactic strategies that are designed and operated in subjects of practical orientation and to analyze them from the opinion of students and teachers. To do this, it is assumed that the use of

technologies has different levels of effectiveness in declarative knowledge (theoretical knowledge) in relation to procedural knowledge (practical and execution knowledge), having greater difficulties to achieve significant learning in the latter, given the emphasis on the appropriation of skills and abilities that require mostly the practical execution of activities to achieve the development of competencies stated in the graduate profile.

Institutional Educational Model of Universidad Veracruzana

The Universidad Veracruzana (UV) integrates four dimensions in its educational model: intellectual, human, social and professional. To address them, it aims to develop in the student not only knowledge, but also skills and attitudes. From this perspective, the model is made up of three axes: theoretical, heuristic and axiological, which aim to give it a comprehensive character.

The main characteristics that define the UV educational model are transversality and integrality. Transversality refers to the way in which theoretical, heuristic and axiological knowledge is presented in the different subjects of the curricular map. Integrality refers to the articulation of all the elements in the student's trajectory, strengthening the development of strategies for the search for innovative solutions and the formation of professional, human and social values (Universidad Veracruzana, 2013).

The training areas of the UV educational model are divided as follows: Basic Training Area, Disciplinary Training Area, Terminal Training Area and Elective Training Area.

As mentioned, the proposed model includes three integrating axes: theoretical axis, which refers to the ways of approaching the study; axiological axis, which focuses on ensuring that the student's education, in addition to being pertinent in terms of content, is aware of human and social values; and the heuristic axis –which is the one that interests us– "this is based on the development of skills, procedures and processes that offer a possibility of solving a problem" (Universidad Veracruzana, 1999). This axis seeks to foster in the student the development of capacities that allow him to take theoretical knowledge, and through processes such as analysis or research, be able to solve problems. The model emphasizes that this should not be approached in a decontextualized manner, and also seeks to make the way of solving problems creative.

Research context

One of the main characteristics of the UV Agricultural Production Systems Engineering (APSE) program is a balance between theoretical and practical hours. This situation means that the subjects must be supported by classroom hours, laboratory hours, extramural practices, field practices or academic stays that involve students in direct learning experiences. This allows, in some way, that the theory addressed during classes is contrasted with reality and vice versa. This is consistent with the components of competencies, as the skills, knowledge, and attitudes are evident in practical application and real-world problem-solving.

By its nature, the APSE degree incorporates knowledge from different disciplines, by maintaining a systemic approach, knowledge from areas such as agronomy, veterinary science and animal husbandry, biology, mathematics, economics, administration, computer science, sociology, public health, engineering, legislation, ecology and systems converge. In this way, its study plan allows the program to address topics such as production systems, food production; agricultural technology, human, animal and plant health, natural resource management, sustainable development, among others. With the support of these disciplines, the degree allows:

> articulate knowledge to design specific production systems, referring to food sources of animal and plant origin, as well as the rescue, conservation, preservation and management of natural resources, structured in such a way that they aim to transform traditional models of agricultural and livestock exploitation into integral and sustainable production units, in economic entities defined and organized with a business sense and environmental protection (Universidad Veracruzana, 2015, p. 40).

Therefore, the focus of this degree involves practical learning and has at least three important aspects to highlight: 1) the systemic and therefore interdisciplinary approach by encompassing different disciplines, 2) the interaction that must be maintained with the different social sectors - real learning environments - to promote the training of its students and, 3) the fact that the degree is taught in the non-school modality - virtual educational option, which implies challenges in the use of ICT in practical degrees.

Teaching strategies related to know-how

In various research studies related to didactics, the activities and the ways in which they mediate the construction of knowledge, communicative interaction and, consequently, how they can generate comprehensive learning are mainly analyzed. However, beyond learning outcomes, research has incorporated other variables, such as teaching strategies, the nature of the subject matter, and the social, institutional, and personal contexts (Longhi *et al.*, 2020).

According to the guidelines, the characteristics of the virtual educational option are the following:

- There are no spatial coincidences between educational actors.
- Adjust to a flexible schedule and calendar.
- Technological mediation is required for teaching and learning processes (DOF, 2018).

The mastery of theoretical knowledge, heuristics, skills and abilities, and axiological knowledge, attitudes and values, depends to a large extent on the approach that the teacher takes to meet the course objectives. This also depends on the course design on the virtual platform and how it promotes learning.

The success of strategies requires a variety of circumstances and situations. Among others, the design of these is associated with:

- Knowledge about how the student learns – identification of prior knowledge, life history, learning styles.
- Organization of information, gradualness of content, search for appropriate languages, contextualization of teaching materials.
- Teaching activities aimed at managing learning in an individual and collaborative manner, in accordance with the particularities of the students.
- Motivation in students regarding the intentions of the contents.
- In current curricula based on the development of competencies, it is necessary to strengthen student-centered teaching and learning processes – reasoning, self-learning, collaborative learning.

From a constructivist perspective, the way in which students learn, that is, how they construct their knowledge, is of vital importance. In this sense, it is proposed that the student's cognitive activity occurs when learning scenarios recognize prior ideas, life history, the practical nature of learning, the student's emotional disposition to learning, the lack of meaningless memorization of information, and the promotion of the formation of critical

attitudes with reasoned criteria to discern reality. This environment generates the possibilities of constructing knowledge individually and collectively through discovery.

In this regard, Ausubel and Novak (1978) and Godwin (1989), as cited in Domínguez *et al*. (2021) state that learning is intelligent if it is meaningful and it is so if the subject possesses concepts capable of giving precise meanings to the experience. If not, learning becomes mechanical: experience conditions subsequent learning in a less conscious way, producing mere habits. Furthermore, learning is intelligent if it is reflexive, that is, if the subject acts on hypotheses and analyzes the results trying to grasp the links between ideas and facts, modifying subsequent attempts accordingly. (Dewey, 1989; Schön,1993; as cited in Domínguez *et al.*, 2021).

For the purposes of this research, it is interesting to explore how effective teaching strategies geared toward the "know-how" of the profession have been in promoting relevant learning in students enrolled in the APSE program.

Method

The research methodology used was mixed, since it incorporates both qualitative and quantitative tools. The design used was sequential exploratory. First, it is qualitative as it focuses on understanding and interpreting phenomena, exploring them from the perspective of the participants in a natural environment and in relation to the context (Hernández Sampieri and Mendoza Torres, 2018). Inductive reasoning predominates in this type of research, that is, individualities are explored to generalize and generate theories; it is naturalistic since the cases are studied, the way in which they occur and are perceived; it is interpretive, since it provides an explanation of the phenomena based on the opinions of those involved and the researcher (López *et al.*, 2020). It is quantitative, since it involves a process of collecting, interrelating, analyzing and triangulating data in the same study context to address the problems (Carhuancho *et al.*, 2019).

Initially, a documentary review was carried out using the content analysis methodology to identify two areas of relevance for this study: a) identification of the teaching strategies most commonly used in the subject programs. In this context, a total of 46 compulsory subject programs were analyzed, from which the most frequent teaching strategies described in the methodological strategy section were taken and, b) identification of the heuristic knowledge related to the know-how of the profession stated in the graduate profile and in the subject programs of the study plan.

In a second phase, a semi-structured survey was applied, which allowed for obtaining relevant information on the perception of students and teachers, as well as more in-depth assessments of the phenomenon studied. The instrument consisted of closed questions with an open field for explanation (Álvarez-Gayou, 2003).

The surveys were piloted with 25 students from the Agricultural Production Systems Engineering program, and 10 experts on the topic were intentionally selected. Three fundamental aspects of the semi-structured surveys were reviewed: a) clarity and relevance, in order to pose clear, concise and understandable questions for the participants, avoid ambiguities and ensure that they were related to the research objectives and topics of interest; b) coverage, with the intention of covering an adequate range of topics and subtopics relevant to the research objectives; and c) neutrality, with the purpose of avoiding biases or suggestions that may influence the participants' responses. Based on these criteria, the surveys and preconfigured options were adjusted after the pilot study.

The survey focused on investigating three fundamental aspects:

- Structure and operation of courses, virtual platform, online classes.
- Teaching and learning processes oriented towards Know-how (heuristic knowledge)
- Characteristics and appropriation of the competencies stated in the graduate profile, associated with know-how.

The type of sampling carried out was non-probabilistic and for convenience, in this way it was considered that the total student population of the Faculty of Engineering in Agricultural Production Systems is 487 students, 218 for the virtual educational option.

Thirty-eight students enrolled in the last semester (february-june 2022) of the virtual program were interviewed. Final-semester students were selected because they are a few months away from graduation and have completed 95% of the credits required for the degree. This allows them to have a comprehensive assessment of the training received.

Similarly, a survey was applied to 13 Full-Time Professors (FTP), representing to the total number of contracted professors in this category, with the purpose of exploring the teaching strategies that are carried out to promote procedural learning.

Results

Regarding the first stage of the study, a total of 46 subject programs were analyzed, from which the most frequent teaching strategies described in the methodological strategy section, referring to know-how, were taken, which were:

1.- *Simulation of realities*. Proposal of alternative solutions to real problems in the environment, from different approaches and through teamwork.

2.- *Laboratory practices*. Development of experiments or analysis for the acquisition of skills and abilities for mastery of the discipline.

3.- *Field practices*. Internships at the actual site of the problem to put knowledge, skills and abilities into practice.

4.- *Problem-based learning*. A problem that has been taken from reality and that is analyzed and alternative solutions are proposed among small groups.

5.- *Project Development*. Development of work during or at the end of the period in which acquired knowledge is integrated with the practice carried out and which allows the integration of theoretical, heuristic and axiological knowledge.

Regarding the graduate profile, it was found that the engineer in Agricultural Production Systems generally acquires the following characteristics:

- The design and operation of conventional and alternative agricultural production systems, for urban and rural areas, under schemes of productive and economic efficiency, health, added value, organization, sustainability, security and food safety.
- The comprehensive management of natural resources, according to their potential, for their optimal and sustainable use, conservation and remediation.
- The management and implementation of policies and programs that guarantee food security and sustainable rural development.
- The development and implementation of innovative human resource training programs for the generation and transfer of knowledge and technology.
- The design and operation of sustainable agricultural production chains, under national and international standards, based on the identification of trends and the analysis of market behavior (Universidad Veracruzana, 2015, p. 140).

Once the main teaching strategies related to know-how and the knowledge, abilities, skills and attitudes described in the graduate profile were identified, the perception of students and teachers was investigated regarding how they assume what is stated in the formal document of the study plan and daily practices in virtual sessions.

In this context, with regard to the effectiveness of the medium for addressing knowledge, the questions were first asked about the use and effectiveness of the technological platform, the relevance and effectiveness of the strategies related to the knowledge of the

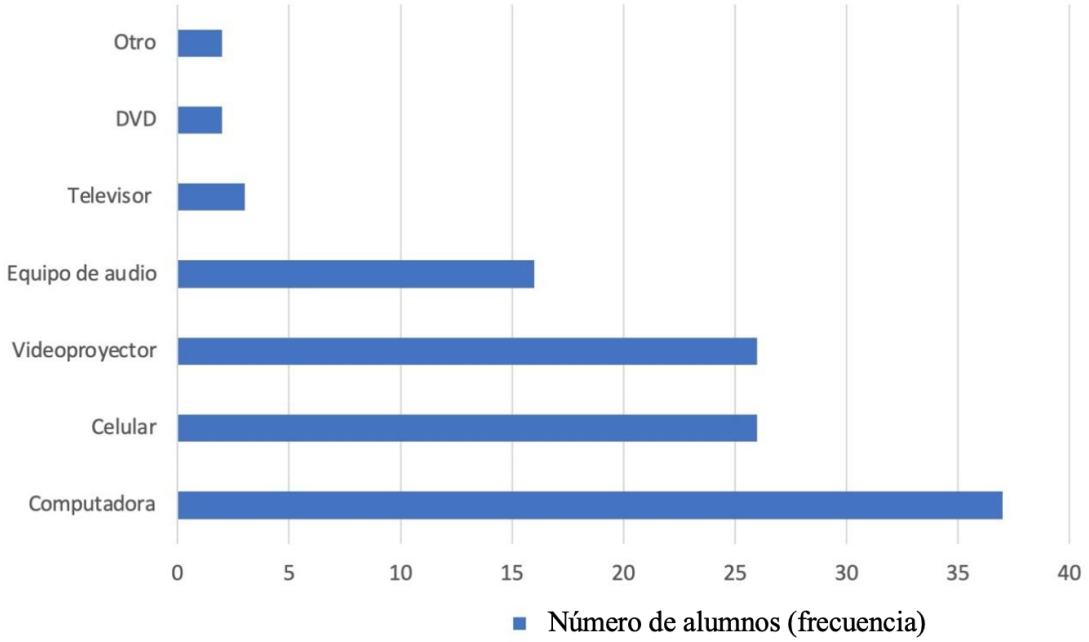
profession and, finally, their correspondence with the achievements stated in the graduate profile.

Using the technological platform

The FTP and the students of the program included in this study were interviewed. The different technological tools used in the courses were analyzed, and they were questioned about their usefulness and what the main obstacles to carrying out the sessions were.

As can be seen in Figure 1, the devices most used in classes are the computer, the cell phone and the video projector, with less use of the television and the DVD, devices that have increasingly fallen into disuse due to the rise of others with more divergent functions and greater utility options.

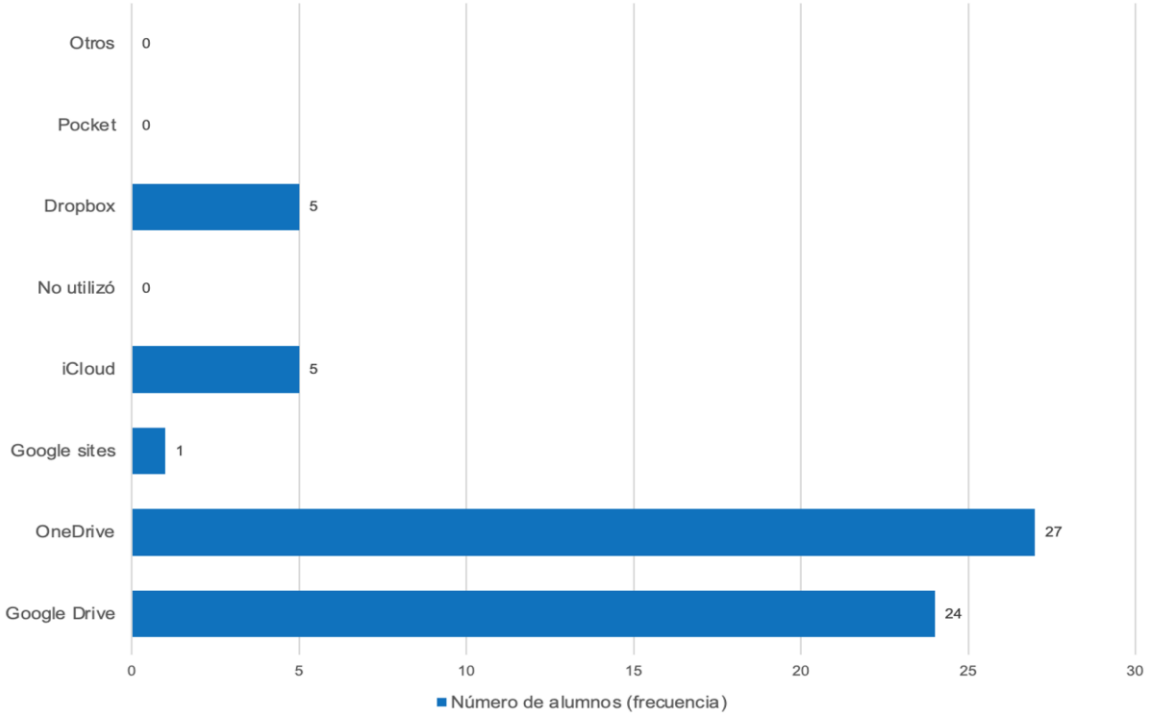
Figure 1. Support technological devices in courses.



Source : Own elaboration.

On the other hand, in Figure 2, referring to the use of applications for data storage, this was the behavior of the responses, with the predominant use of OneDrive, followed by Google Drive and Dropbox. OneDrive is a tool provided by the institution that allows storing and sharing files of unlimited size, which explains its majority use over the other options and represents a key tool in the interaction between teachers and students.

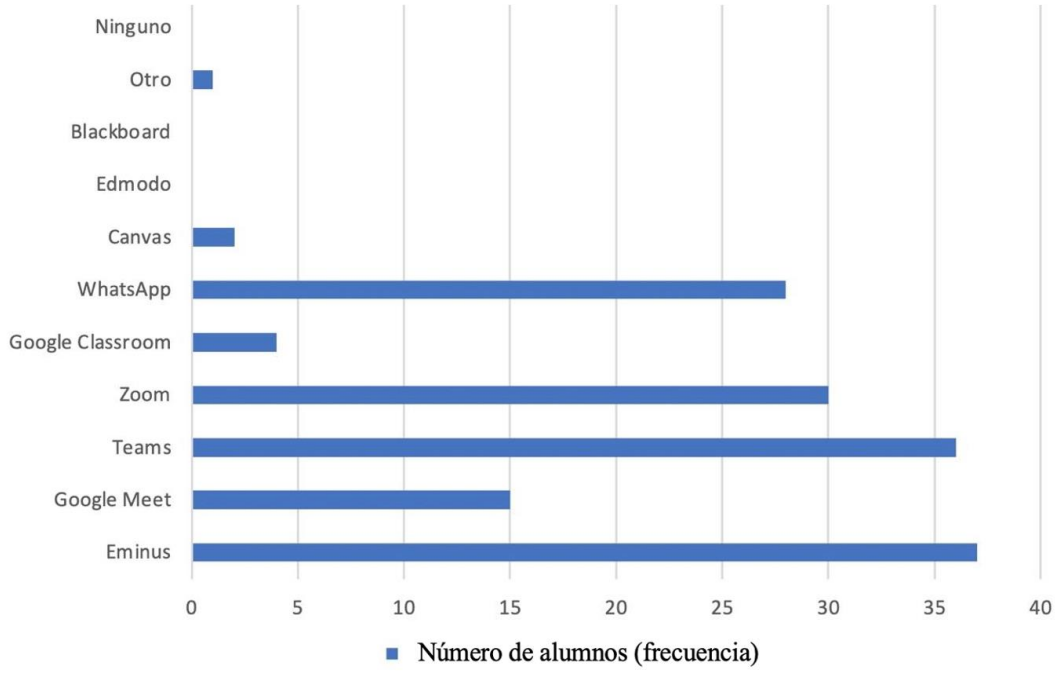
Figure 2. *Applications for data storage in classes.*



Source : Own elaboration.

In order to find out how often they used platforms that allow incorporating and combining courses with a more complete instructional design, that is, platforms that allow the convergence of teaching media, in which tasks and activities can be assigned, virtual classes can be held, evaluations can be made, the progressive progress of students can be observed, and this form can be graded, they were asked which ones they regularly used in their courses, with the data obtained being shown in Figure 3.

Figure 3. *Supporting communication software used in courses.*



Source : Own elaboration.

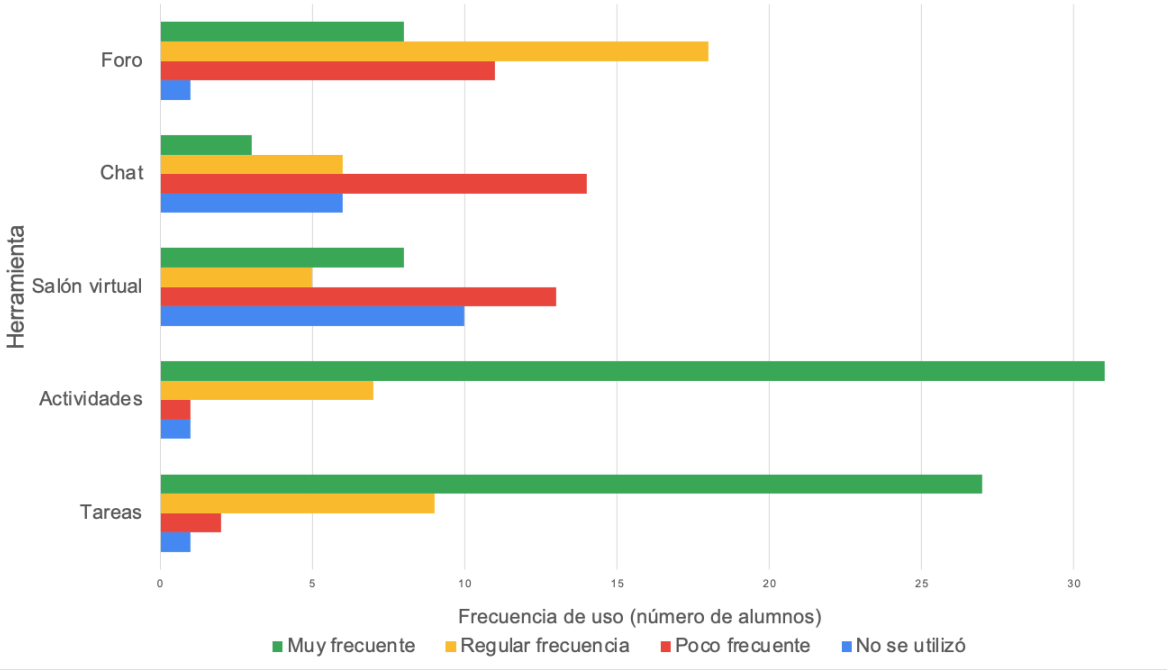
As can be seen, the *Eminus institutional platform* is the most used tool to carry out the course, since all subjects are incorporated into it. As a means of teaching sessions through videoconferences, teachers use this platform first, Teams in second place, Zoom in third place, followed by WhatsApp, Google Meet, Canvas and finally Google Classroom.

The diversity of tools used in the courses by teachers can be noted, since in addition to having their course incorporated into *Eminus*, they use other means both to communicate with students and to teach virtual classes. In this case, we have an intensive use of videoconferencing, as can be seen through Teams and Zoom. The frequency with which WhatsApp is used cannot be overlooked, despite not being a tool that integrates diversified options for learning, more than half of students say they use it regularly for the development of teaching and learning activities.

These initial questions were intended to investigate the type of tools used by teachers and to find out whether these tools were linked to a pedagogical use that allowed access to various contents, the development of practices and establishing conditions for meaningful learning in terms of know-how.

Since all teachers use the *Eminus platform*, they were asked about the platform's own options for the organization and operation of the course. In this sense, we based ourselves on the main functions it contains, which is shown in Figure 4.

Figure 4. *Tools incorporated into the virtual platform with their frequency of use.*



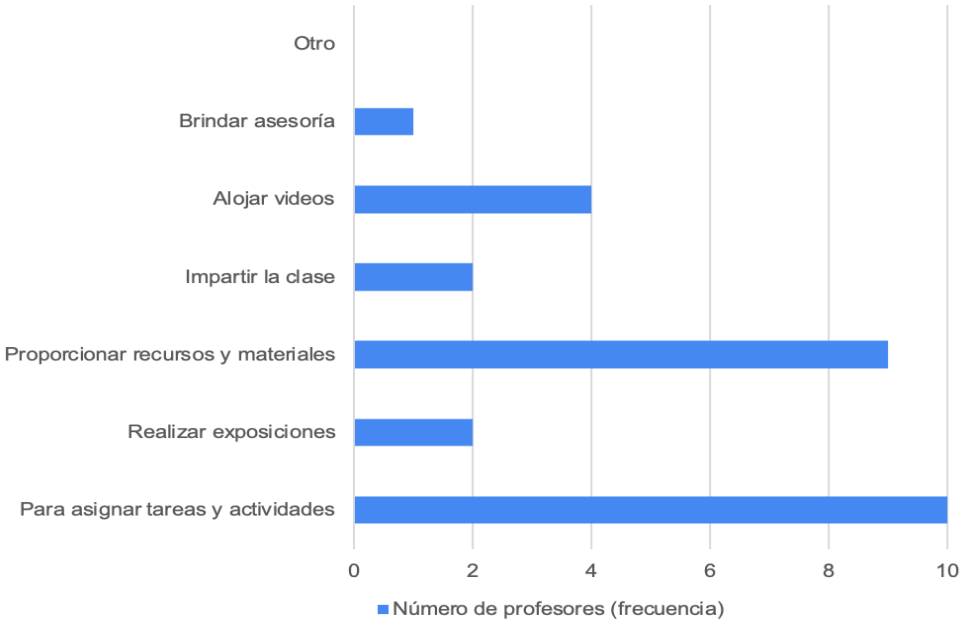
Source: Own elaboration.

Most teachers and students use the platform in their courses to assign activities and tasks, to a lesser extent, less than 50%, use the virtual classroom, followed by the forum and finally the chat. Around 40% indicate that they did not use the chat, the virtual classroom or the forum. In conclusion, the most frequent use they give to the platform is for carrying out activities and tasks.

To investigate this further, the FTP were asked more precisely about activities not necessarily associated with the sections contained in the platform, but rather about those actions aimed at supporting the teaching strategies they develop during class sessions and which are related to the disposition and the different ways of approaching the content.

The activities that they indicate as most frequent are shown in Figure 5.

Figure 5. *Main uses given to the platform that FTP claim to use.*



Source : Own elaboration.

In response to the question about the uses given to the platform by teachers, almost all of them state that they use it to assign tasks and activities, as well as to provide resources and materials. To a medium extent, it is used for hosting videos. Meanwhile, to a lesser extent, it is used to teach class sessions and for their students to make presentations on the course topics, as well as to provide advice to their students.

This use is more of a reservoir of content and less oriented towards interaction as a virtual classroom space, since one of the benefits attributed to virtual reality is the possibility of providing fictitious environments that can facilitate the development of scenarios that simulate reality and thereby strengthen the representations that can be made of human interactions. In this context, the use they declare is more as a means of content provision rather than interaction as a means of provoking learning.

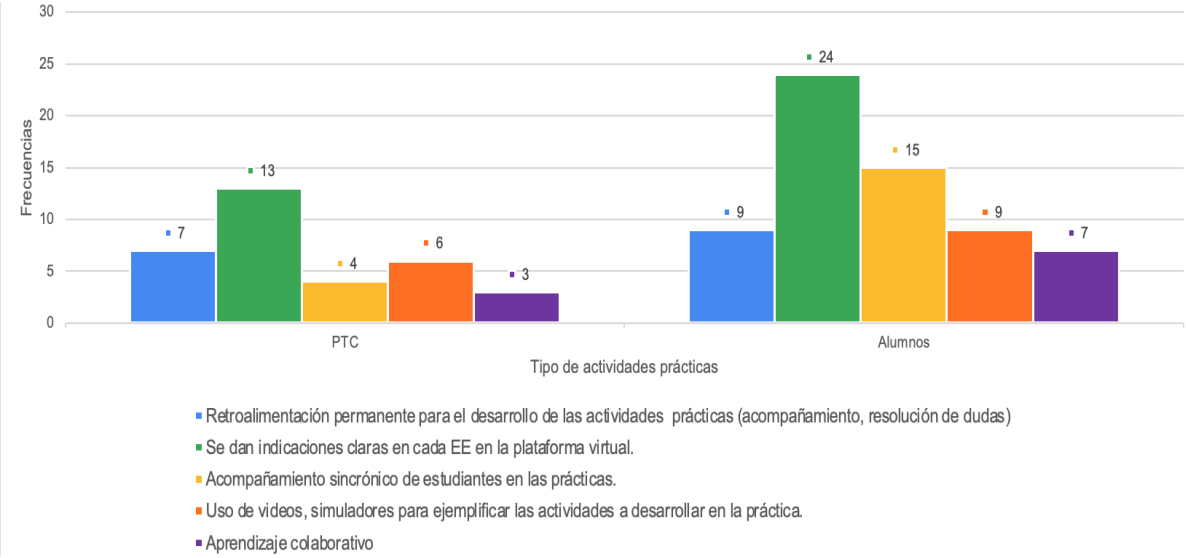
Another of the questions that sought to investigate not only descriptive aspects, but to delve deeper into the difficulties that teachers face with the virtual platform, was to know the difficulties of a technological nature and those that corresponded to pedagogical aspects. In this regard, all teachers commented that they had had technological difficulties in teaching their courses and, to a lesser extent, they also presented pedagogical difficulties related to the way of teaching the class virtually, as well as complications in the subject of interaction with students.

In this framework, we investigate the teaching strategies mediated by the technological tools that teachers most frequently use, we explore those that they consider most effective, how they perceive and visualize them to enhance learning, specifically in the know-how of the profession.

Analysis of the perception of teaching strategies used by teachers and students

We consider resuming the results by presenting the points of convergence between the opinions of teachers and students, as well as showing the contrasts in the responses. In this sense, we present in Figure 6 the response provided by teachers regarding the way in which they view the development of practical activities that could enhance learning:

Figure 6. *Type of practical activities developed by the FTP and students.*



Source : Own elaboration.

In general, it is mentioned that for the realization of practices (laboratory and field), the course approach is clear in the indications of how they should be carried out, the instructions are generally precise and guide the development of these activities. Almost half of the students claim to have had **synchronous support** from the teacher in the development of their practices, while less than half of the teachers claim to have provided synchronous support in their practice sessions.

The use of illustrative videos or simulators to guide the implementation of practices is crucial, especially videos that exemplify how certain activities should be carried out to

allow the acquisition of skills and abilities and thus the mastery of certain techniques specific to the exercise of the profession. In this context, almost half of teachers and a quarter of students mention having resorted to this type of strategy. It is important to note the use of video as a teaching medium in virtual and distance education, since through them, realities can be developed in a simulated manner that exemplify the mastery of certain skills and abilities that must occur in direct experience.

The next item analyzed corresponds to analyzing the effectiveness of the follow-up through the virtual platform and thus investigating the perception that students have about the **feedback received** during the development of their practices. Here, the support to clarify doubts about the implementation of this type of activities was questioned. Half of the teachers indicated that they addressed the doubts and issued guiding comments during the development, while only a quarter of the students indicated that they received such attention.

In addition to the previous question and with the purpose of identifying the possibilities of **collaborative learning** in problem solving, the question was asked about the realization of field and laboratory practices with other classmates to try to assess how they propose alternative solutions to problems that they identify on the fly. In this regard, approximately 20% of teachers and students declare having developed practices in a team or with some of their classmates.

In summary, several important aspects can be seen in the responses provided. The platform is explicit in terms of the guidelines and instructions for the development of teaching and learning activities based on laboratory and field practices. Regarding the synchronous accompaniment of the professor, although there is a discrepancy in the answers provided by the students with those of the professors, it allows us to infer that less than 50% of the practices had direct participation from the professors who guided their development.

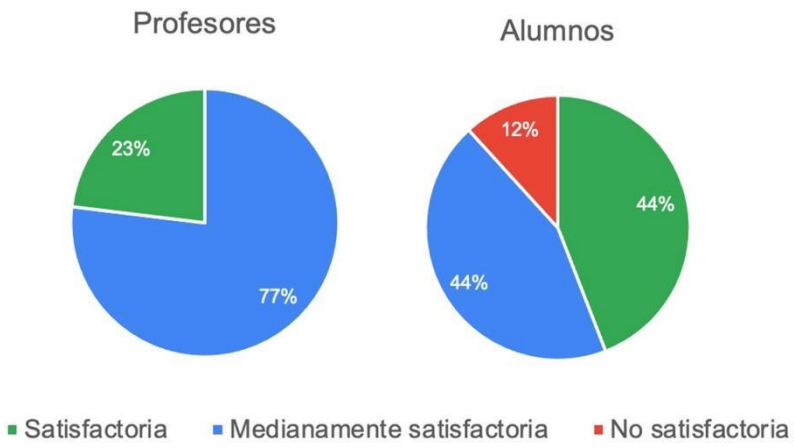
It is worth highlighting the contrasts found in the answers to the question related to the feedback given during practical activities, where a low percentage of students indicate having interaction with their teachers, while around 50% of teachers say they have provided such feedback. In both cases the percentage is low, considering that students later rate the teachers' intervention negatively. In this same sense, in the item related to the demonstration of how to carry out the practices based on videos or simulators, very few students report having relied on this strategy and less than 50% of teachers implemented it.

Finally, students and teachers agree that the implementation of the practices does not occur in this case in a collaborative manner; a small percentage had the experience of carrying

them out with the support of their classmates. This reflects that when carrying out a learning activity in the environment, students have little advice from their teachers and it is not possible to propose joint alternatives with their classmates.

In this line of thought, they were asked about their perceptions of the development of teaching and learning strategies associated with practical activities.

Figure 7. *Perception of practical activities undertaken with students.*



Source : Own elaboration.

As can be seen in Figure 7, only 44% of the students report that the practical activities are satisfactory, with 12% even saying that they are not satisfactory. When investigating these aspects in more detail, they were asked through open questions to describe why they considered them to be unsatisfactory and moderately satisfactory. In this regard, they gave their opinions on aspects of a mainly pedagogical nature. The main opinions expressed are summarized here:

It wasn't always possible to go out to an optimal place for practice.

Some topics were missing from some experiences due to lack of time; therefore, the practices were at home, although the teachers gave precise instructions in eminus, it is always better with synchronous accompaniment from the teacher due to the feedback that may arise at the time.

I believe that more than theory, we should have more practical knowledge to better understand the activities and the reasons for each of them.

Moderately satisfactory since the activities are only on the computer and there are not many field practices, which are what interest me.

All the practical work is done from home, the teachers help us by giving us the theoretical part and the follow-up, and we as students have to send evidence of the practices that we do; it is more than anything the culture of each one as a student or the responsibility to acquire new knowledge. Obviously in the faculty there are face-to-face practices and if you are interested as a student you can attend , it is up to each one.

Of the 8 subjects that I am currently taking, only two EE are those with which there have been face-to-face or home practices (sic) and reports are sent.

Because not all EEs had internships and some only offer activities.

There are teachers who do not answer emails

It can also be noted that, as it is a program that operates as a virtual educational option, the implementation of the practices in which students can acquire skills and abilities and put into practice problem solving, seems to be subject to the autonomy of the learning process by these; it is noted that there are clear rules for carrying out the learning activities, however, during the execution process there are doubts that arise derived from the changing reality and that the solution to the problems is not unidirectional and has various aspects, at those moments the student faces dilemmas, uncertainties, a crucial moment for the construction of knowledge that can take several edges, a) the individual generation of alternative ideas to the problem posed, b) collective construction of proposals for different procedures for solving the problem and, c) the collective construction of knowledge through the scaffolding of the teacher. These three scenarios seem to be limited by virtuality, to some extent environments are not favored for the mastery of specific skills and abilities of know-how.

In this regard, the contrast in the perception held by teachers stands out, and they generally point out positive aspects:

The objectives and goals set out in the program have been achieved.

I have observed that students understand the concepts adequately.

Students acquire theoretical skills and this allows them to perform well in the practical part.

In the case of educational experience, evidence is a file where the fulfillment of the assigned activity can be demonstrated.

Activities are generally delivered according to the requested description, and feedback is also provided in some platform sessions via videoconference.

There is no custom for doing things online.

Internships are optional, and most students are job-seekers, so few do them.

With a well-founded teaching-learning strategy and feedback to students, there is a satisfactory practice.

It is difficult to do practices at home, it is limited, since at the faculty you can find everything necessary, the facilities, the supplies and the manuals to do the practices.

There are few students who do not hand in their assignments.

Students comply with what is requested in the practice rubric.

The competencies of each unit have been understood.

There is a high percentage of students who have completed the course and many of them have obtained laudatory grades.

So far we have investigated the way in which practical activities (laboratory and field) are operated in the educational program to favor the learning processes. The discrepancy in opinions can be seen in the comments made by students and teachers. On the one hand, students think there are no scenarios to fully exercise heuristic skills, and on the other hand, teachers remain optimistic about the appropriation of knowledge in the practices that students carry out in a mostly autonomous way. Although this is not the subject of this research, it can be observed how, from the different spaces held by the educational actors, they hold different opinions.

In order to investigate the teaching strategies that delve into the know-how of the profession, the most used strategies were analyzed and how their effectiveness is perceived for the fulfillment of the graduate profile. The strategies that enable concrete knowledge of the environment are relevant because students approach the surrounding reality, where they interact not only with the agronomic object of study of the discipline, but also with the social environment. The student approaches these realities with a previous theoretical apparatus through which he assimilates, confirms or discards these preconstructed notions. In this dialectical interaction with reality, knowledge is built that encompasses theoretical notions and their refutation or approach to reality itself, at the same time it enhances thought insofar as reality presents various paths of interpretation and solution to problems. The immediacy imposed by the interaction with reality triggers different heuristic tools with which to face the vicissitudes and build learning.

As previously stated, the following teaching strategies were taken as a basis, as they are the ones most commonly used in the subject programs:

1.- **Simulation of realities**. Solve a real problem in the environment and propose alternative solutions, from different approaches and through teamwork.

2.- **Laboratory practices**. Development of experiments or analysis related to the knowledge of the profession.

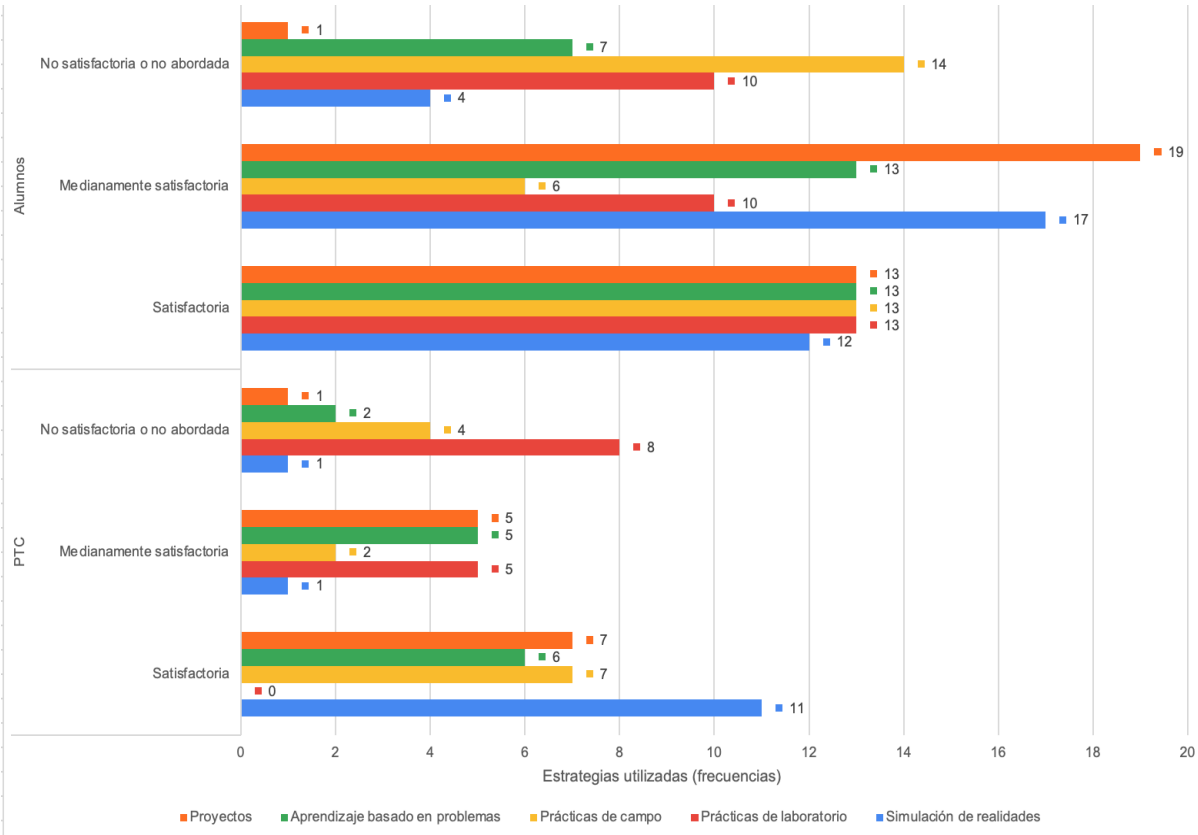
3.- **Field practices**. Internships at the actual site of the problem to put into practice knowledge, skills and attitudes in real scenarios.

4.- **Problem-based learning**. Problems that have been taken from reality in which they are analyzed and alternative solutions are proposed among small groups.

5.- **Projects.** Development of work during or at the end of the period in which acquired knowledge is integrated with the practice carried out.

In this regard, the following results were obtained as shown in Figure 8.

Figure 8. *Opinion of FTP and students regarding the teaching strategies used according to their use.*



Source : Own elaboration.

We can see that the teaching strategies evaluated mostly as moderately satisfactory were those related to the simulation of realities and the realization of integrative projects, followed by problem-based learning, laboratory practices and field practices to a lesser extent. It is noteworthy because in this case we are referring exclusively to the implementation of strategies that place the student in real learning scenarios and it is where

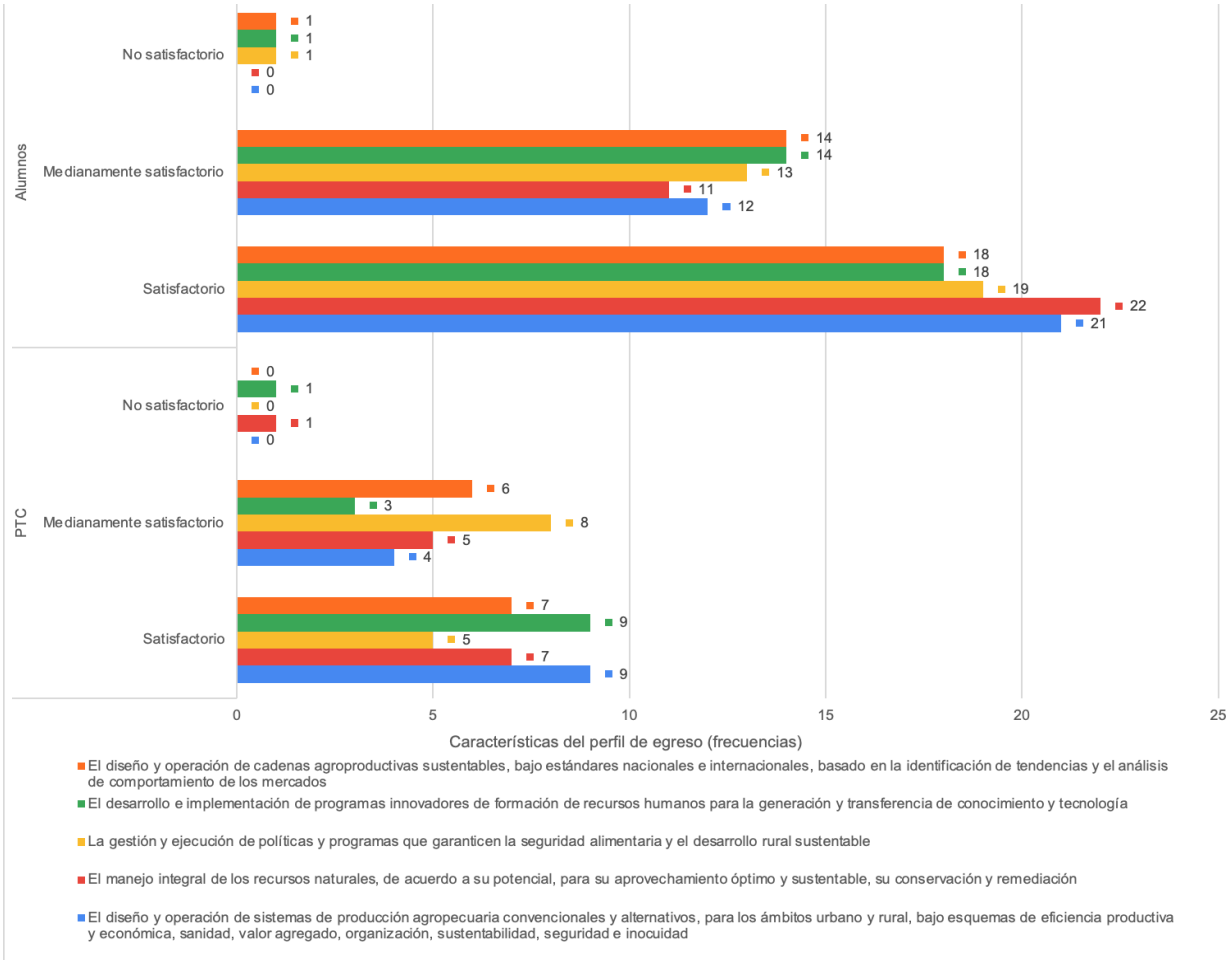
skills, abilities, attitudes are developed and alternatives are proposed to the problems that arise.

In general, these teaching strategies aimed at developing the know-how of the profession are valued as satisfactory in a percentage of less than 50% and in all of them a percentage of dissatisfaction is also described: mainly field practices by students, and laboratory practices by the FTP. This situation must be reflected if we consider that one of the main characteristics of the Bachelor's Degree in APSE is to be a Scientific-Practical program. Although the educational model is based on the theoretical/epistemological, axiological and heuristic dimensions, to a large extent heuristic knowledge constitutes a crucial part for the training of the student in the disciplinary competences and in the fulfillment of the graduation profile.

In this regard, students were questioned about the contribution of the knowledge acquired to meet the graduation profile, which has different components related to the mastery of skills and abilities, which were stated above.

Figure 9 shows the behavior of the responses.

Figure 9. *Opinion of students and FTP regarding compliance with the characteristics expressed in the graduate profile of Agricultural Production Systems Engineering.*



Source : Own elaboration.

It is interesting how the first traits of this profile are evaluated with a higher percentage, decreasing the positive perception of these in those that refer to the implementation of innovative programs, transfer of knowledge and technology, operation of agricultural production chains. That is, those traits that have an important theoretical component, program design, understanding of the systemic approach, knowledge of productive and economic efficiency schemes, aspects of quality and food safety, among others, have a more acceptable perception. In this sense, the understanding of the integral management of natural resources and the knowledge and management of policies oriented to food security and sustainable development also have a higher percentage. However, when we review the aspects related to the implementation of programs, when putting into practice the skills, abilities and knowledge in a specific context, the positive perception score decreases.

In general, students have an acceptable perception of the skills acquired and associated with the graduate profile, but since this is a degree with a strong connection to the realities of the environment, it would be expected that a greater number of students would be satisfied with the strategies used in the courses and in the development of skills that they promise.

Discussion

Teaching strategies are a core part of the teaching and learning processes. Their effective use depends on the nature of the discipline. This undoubtedly has to do with the way in which knowledge is constructed in the natural sciences or engineering, which is different from the way in which knowledge is constructed in social science disciplines with eminently theoretical content. The use of educational technology to promote learning processes is an indispensable element in the current context, since the diversification of teaching scenarios contributes to the construction of spaces conducive to meaningful learning, avoiding monotony in the teacher-course-student relationship, imbuing a playful and creative character in the approach to the different thematic contents that make up a subject, among other beneficial aspects, such as coverage, remote classes, among other things.

In this study, various teaching strategies and technological tools were analyzed in scientific-practical knowledge, so the interaction with real learning scenarios plays a preponderant role, especially for the appropriation of skills, abilities and attitudes, as well as in the resolution of problems in the dialogic relationship that students establish during the implementation of their knowledge. In this sense, teaching strategies related to the simulation of realities, the realization of integrative projects, problem-based learning, laboratory practices and field practices were analyzed. According to these analyses in the know-how of the profession, teaching strategies that incorporate virtual environments require –to be effective–: close accompaniment by the teacher and follow-up in specific activities. Although, in this case, the technological medium facilitates the approach to content in different ways, at the same time it removes the possibility of direct interaction with the teacher or with the students themselves when building alternative solutions to *in situ contingencies* that arise in the development of the subjects. Lack of feedback causes confusion and discouragement, which translates into a lack of motivation to build meaningful learning in relation to the know-how of the profession.

Although technological tools facilitate the diversification of teaching strategies and therefore the fulfillment of the objectives of the graduate profile, their use presents limitations in the area of practical or procedural learning. These limitations mainly hinder direct experience and the practical application of theoretical concepts.

There are few studies that refer to the effectiveness of virtuality in engineering programs in the dimension of "know-how". Most of the research addresses the development of comprehensive competencies and does not disaggregate the analysis by each dimension of this, that is, "know-how", "know-how", "know-how". There are many studies, especially in Mexico, focused on the development of teaching competencies in virtual modalities, but few works develop the impact of teaching strategies on student learning to enable meaningful learning in scientific-practical programs. Some of the studies linked to the subject indicate that technology can provide benefits in the teaching and learning processes, since it promotes the implementation of pedagogical and methodological strategies that are based on collaboration, communication and access to information resources (Moreno *et al.*, 2015; Viveros and Velasco, 2015). Such use of technological resources should not imply a loss of autonomy on the part of the teacher in the process of designing and implementing a training program.

For their part, López *et al*. agree that success depends largely on the teacher's training and the level of mastery in the digital competence of the university professor, such as:

> knowledge about computer devices and tools; design of activities, situations and assessments that incorporate ICT in a contextualized way; implementation and ethical, legal and responsible use of ICT; transformation and improvement of professional teaching practice (individual and collective); efficient treatment and management of existing information on the network; use of the network for collaborative work, communication and interpersonal interaction and support for students to appropriate ICT and demonstrate competence in their use (2017, p. 96).

A study in Ecuador carried out by Arias *et al.* (2022) in engineering programs analyzed the effectiveness of addressing general and specific competencies in the planning of integrative projects. The results demonstrated a link between scientific, technical and axiological knowledge during its development, managing to strengthen in students some of the general and specific competencies of a civil engineer. However, what was referred to as "know-how" was not specified in this study.

In a study carried out in Argentina, also in engineering courses, it was investigated whether students generated various alternative solutions to a problem already formulated, as well as whether they developed professional criteria for the evaluation of the alternatives and selection of the most appropriate one for a particular context. It was found that the employer sector required greater knowledge than that learned by the students, which showed that the expected learning was below the expectations of employers (Susana, 2018).

In this sense, previous studies attribute, as expected, the success of the technology-mediated teaching strategy to the teacher's performance. In the study that we conducted and that had the purpose of investigating teaching strategies, we found that in addition to the crucial role of the teacher, their effective use depends on certain strategies depending on the nature of the discipline. This undoubtedly has to do with the way in which knowledge is constructed in the natural sciences or engineering, which is different from the way in which knowledge is constructed in social science disciplines with eminently theoretical content.

A fundamental aspect of training is the integration of different types of knowledge, as proposed by authors such as Schön (1984) and Tobón (2008). This knowledge, which makes up the professional identity, must be the object of critical reflection during the learning process. This transdisciplinarity in training is essential to address the complexity of current problems (Morín, 2007).

From an epistemological and psychological perspective, the construction of knowledge involves the interconnection of different models of explanatory knowledge that the professional develops throughout his career. The objective is for the professional to develop a complex, articulated theory with multiple relationships that guides his professional practice (Cuadra *et al.,* 2018). In this context, practical knowledge is important in the development of competencies since it allows building learning in the very execution of the students' performances.

Conclusions

University courses, depending on the discipline and the interdisciplinary approaches that support them, are oriented towards theoretical or practical areas or the complementarity of both. By their nature, courses linked to engineering have an important link with the development of learning activities in the students' surrounding environment that should allow them to appropriate the knowledge stated in the graduate profile. That is why this study consisted of investigating the didactic strategies that favor the development of significant learning in the "know-how" under a virtual modality.

Important findings include the fact that the courses operate under a virtual platform where clear instructions are generally provided for the different activities carried out, innovative tools are used that allow the appropriate hosting of information, and the structure of these is adequate. The institutional platform allows the use of different interactive tools, such as: chat, virtual classroom, and advice, which, according to those surveyed, are rarely used.

The tendency to use a variety of technological means to strengthen teaching and learning processes, specifically in higher education in non-school mode, leads us to rethink what types of content and characteristics of educational programs are likely to optimally transition to the different options, specifically the virtual one, and under what pedagogical conditions.

It can also be inferred that the success of meaningful learning depends largely on the application of appropriate teaching strategies and teacher support. Of course, technological tools, if used correctly, can be a valuable resource to complement theoretical learning and achieve the objectives of the graduate profile.

Additionally, students point out limitations in the use of these tools for "practical" learning, which restricts direct experience and the development of skills and abilities, since these cannot fully represent real experience. Therefore, it is necessary to explore strategies that combine theoretical learning mediated by technology with practical experiences for comprehensive training. These strategies must consider the specific needs and characteristics of each discipline and educational context.

The limitations of technology in the practical field of learning require strategies that integrate direct experiences and support from the teacher for the optimal development of skills and abilities.

Future lines of research

A large amount of literature and research on the use of technology refers to the benefits of these in the diversification of educational modalities, and a certain positivity is assumed in themselves. What this study reflects is that, in educational programs that incorporate content that requires practice, there is not a completely satisfactory perception of the strategies that are built mediated by ICT to favor certain learning oriented to the know-how of the profession.

The tendency to use a variety of technological means to strengthen teaching and learning processes, specifically in higher education in non-school mode, leads us to rethink which types of content and characteristics of educational programs are likely to optimally transition to the different options, specifically the virtual one, and under what pedagogical conditions.

In this context, it is necessary to expand research that delves into the appropriate strategies for efficiently operating educational programs and promoting the development of good practices, in accordance with the graduate profiles, objectives or defined competencies.

It will be important to identify the barriers and challenges not only of teachers and students, but also of the administrative structure and physical infrastructure, and above all the nature of the educational programs and the competencies that are intended to be achieved in order to promote innovations. In this context, it is essential to research and develop new methodologies that optimize the use of technology for practical learning, guaranteeing the development of relevant skills and abilities.

References

Álvarez-Gayou, J. (2003). *Cómo hacer investigación cualitativa Fundamentos y metodología*. Paidós Mexicana. http://www.derechoshumanos.unlp.edu.ar/assets/files/documentos/como-hacer-investigacion-cualitativa.pdf

Arias Rueda, C.A., Arias Rueda, J. H. y Arias Rueda M. J. (2022). Desarrollo de competencias de ingenieros civiles en formación a través de proyectos integradores. *Revista de Ciencias Humanas y Sociales*, 96(2021), 142-164. https://doi.org/10.5281/zenodo.7470628

Barrera, F. y Linden, L. (2009). *The use and misuse of computers in education: Evidence from a randomized experiment in Colombia* (Documento de trabajo de investigación No. 4836). Política del Banco Mundial. http://ssrn.com/abstract=1344721

Carhuancho-Mendoza, I. M., Sicheri Monteverde, L., Nolazco Labajos, F. A., Guerrero Bejarano, M. A. y Casana Jara, K. M. (2019). *Metodología de la investigación holística.* GUAYAQUIL UIDE. https://repositorio.uide.edu.ec/handle/37000/3893

Castañeda, L. y Selwyn, N. (2019). *Reiniciando la universidad: Buscando un modelo de universidad en tiempos digitales.* UOC.

Cobo, C. y Moravec, J. (2011). *Aprendizaje Invisible: Hacia una nueva ecología de la educación.* Col-lecció Transmedia XXI. Publicacions i Edicions de la Universitat de Barcelona. https://www.uv.es/bellochc/MasterPoliticas/Cobo_Moravec.pdf

Cuadra-Martínez, D.J., Castro, P. J. y Julia, M. T. (2018). Tres saberes en la formación profesional por competencias: Integración de teorías subjetivas, profesionales y científicas. *Formación Universitaria*, 11(5), 19:30. https://dx.doi.org/10.4067/S0718-50062018000500019

De Souza Santos, B. (2020). *La cruel pedagogía del virus.* CLACSO. https://www.clacso.org/la-cruel-pedagogia-del-virus/

Diario Oficial de la Federación (DOF). (27 de noviembre de 2018). Acuerdo 18/11/18 por el que se emiten los lineamientos por los que se conceptualizan y definen los niveles, modalidades y opciones educativas del tipo superior. https://dof.gob.mx/nota_detalle.php?codigo=5544816yfecha=27/11/2018#gsc.tab=0

Domínguez, M., López-Gómez, E. y Cacheiro-González, M.L. (Coords.) (2021) *Investigación e internacionalización en la formación basada en competencias*. Madrid, Dykinson, 286 pp. https://doi.org/10.15581/004.42.42674

Hernández Sampieri, R. y Mendoza Torres, C. (2018). *Metodología de la investigación: Las rutas cuantitativa, cualitativa y mixta.* McGraw-Hill Education. http://repositorio.uasb.edu.bo:8080/handle/54000/1292

Longhi, A. D., Ferreyra, A. y Paz, A. (Eds.). (2020). *Estrategias didácticas innovadoras para la enseñanza de las ciencias naturales en la escuela.* Jorge Sarmiento Editor, Universitas. https://elibro.net/es/ereader/bibliotecauv/175243?page=1

López Domínguez, A., Díez Fumero, T. y Bernaza Rodríguez, G. J. (2020). *El debate entre lo cualitativo y lo cuantitativo en la investigación educativa de cara a la agenda 2030.* Universitaria.

López Meneses, E, Maldonado Berea, G.A., Marín Díaz, V. y Vázquez Cano, E. (Coords.) (2017). *Investigaciones Educativas Hispano-Mexicanas*. Sevilla: AFOE.

Moreno Anota, Z. E., Viveros Contreras, R. y Velasco Toro, J.M. (2015). Posibilidades de aprendizaje significativo en los foros de discusión virtuales. En Santillán, *Procesos e innovaciones en la educación a nivel superior en Latinoamérica* (pp. 183-197). Guadalajara: CENID.

Morín, E. (2007). Complejidad restringida y complejidad generalizada o las complejidades de la complejidad. *Revista Utopía y Praxis Latinoamericana*, 12(38), 107-119. https://ve.scielo.org/scielo.php?script=sci_arttextypid=S1315-52162007000300009

Pane, J., Steiner, E., Baird, M., Hamilton, L. y Pane, J. (2017). *Informing Progress: Insights on Personalized Learning Implementation and Effects.* RAND Corporation. https://doi.org/10.7249/RR2042

Rodríguez, J., Hunt, G. C. y Barrientos, B. A. (2018). *Cultura digital y las nuevas políticas educativas.* GEDISA.

Schön, D. (1984). *The Reflective Practitioner: How Professionals Think In Action.* New York: Basic Books.

Susana Comoglio, M. (2018). Competencias en carreras de ingeniería. Modelo para evaluar modelos de adquisición y requerimientos del mercado de trabajo. *Revista Iberoamericana para la Investigación y el Desarrollo Educativo.* 9(18), 923-951. https://doi.org/10.23913/ride.v9i18.484

Tobón, S. (2008). *La formación Basada en Competencias en la Educación Superior: El Enfoque Complejo.* Guadalajara: Grupo CIFE.

Universidad Veracruzana. (1999). *Nuevo modelo educativo para la Universidad Veracruzana.* https://www.uv.mx/meif/files/2015/03/MEIF.pdf

Universidad Veracruzana. (2013). *Licenciatura Biología. Plan de estudios 2013*. https://www.uv.mx/biologia/files/2015/08/PLAN-DE-ESTUDIOS-2013.pdf

Universidad Veracruzana. (2015). *Licenciatura Ingeniería en Sistemas de Producción Agropecuaria. Plan de estudios 2015.* https://www.uv.mx/coatza/fispa/files/2015/09/Plan-de-Estudios-FISPA-2015-Extenso.pdf

Viveros Contreras, R. y Velasco Toro, J. M. (2015). Procesos de aprendizaje en modalidades virtuales. *Revista Iberoamericana de Educación*, *67*(1), 101-120. https://doi.org/10.35362/rie671266

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Software	Not applicable
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Writing - Review and editing	Rodolfo Viveros Contreras
Display	Valentin Medina Mendoza
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