CHAKIÑAN
Revista de Ciencias Sociales y Humanidades

UNIVERSIDAD NACIONAL DE CHIMBORAZO

Número 26 AGOSTO, 2025 (224-238)

DIDACTIC STRATEGY BASED ON EXELEARNING FOR THE DEVELOPMENT OF PEDAGOGICAL SKILLS IN BIOTECHNOLOGY STUDENTS

ESTRATEGIA DIDÁCTICA BASADA EN EXELEARNING PARA EL DESARROLLO DE HABILIDADES PEDAGÓGICAS EN ESTUDIANTES DE BIOTECNOLOGÍA

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DOI: https://doi.org/10.37135/chk.002.26.10
Research Article
Recibido: (28/11/2024)
Aceptado: (13/01/2025)

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ABSTRACT

In the modern university, graduates must not only be good professionals but also agents of change capable of acquiring, processing, and communicating knowledge. Based on this approach, a research was developed with the objective of designing a didactic strategy based on ExeLearning to develop pedagogical skills (information processing and assimilation, logic-critical thinking, communication) among seventh-semester Biotechnology students at Ikiam Regional Amazonian University in Ecuador. To analyze the level of pedagogical skills within a population of 77 students, a questionnaire (previously validated by experts with a Cronbach's alpha of 0.77) was administered. Responses were obtained from 30 students, revealing weaknesses in their mastery of pedagogical skills, which would be valuable for their comprehensive professional training, according to their self-assessments. Based on the identified weaknesses and references from the literature, a didactic strategy was designed. Its satisfactory evaluation by experts (Cronbach's alpha of 0.82) supports its implementation within the framework of the program.

KEYWORDS: Education, classroom techniques, virtual learning

RESUMEN

En la universidad moderna, los graduados deben ser no solo buenos profesionales, sino agentes de cambio capaces de adquirir, procesar y comunicar conocimientos. A partir de ese enfoque, se realizó una investigación con el objetivo de diseñar de una estrategia didáctica basada en ExeLearning para desarrollar habilidades pedagógicas (procesamiento y asimilación de la información, lógica-pensamiento crítico, comunicación) en estudiantes de séptimo semestre de Biotecnología de la Universidad Regional Amazónica Ikiam, de Ecuador. Para analizar el nivel de habilidades pedagógicas existente en la población de 77 estudiantes se aplicó un cuestionario (previamente validado por expertos con un alfa de Cronbach de 0.77). Se obtuvieron respuestas de 30 de ellos, que permitieron identificar debilidades en el dominio de habilidades pedagógicas que serían útiles en su formación profesional integral, según las propias valoraciones de los participantes. A partir de las debilidades detectadas y de los referentes de la literatura se diseñó la estrategia didáctica, cuya valoración satisfactoria por los expertos (alfa de Cronbach de 0.82) avala su implementación en el marco de la carrera.

PALABRAS CLAVE: *Educación, técnica didáctica, aprendizaje virtual*

INTRODUCTION

Pedagogical skills are a set of cognitive, practical, and creative activities that educators use to address didactic and academic challenges, thereby ensuring the achievement of the proposed teaching objectives for students (Martínez et al., 2023). These skills influence the comprehensive development of students, particularly in fostering academic competencies such as content assimilation and understanding, critical analysis, efficient problem-solving, effective communication, and more. Pedagogical skills like information processing and assimilation, logic-critical thinking, and communication, should be incorporated into didactic content to guide students toward the optimal fulfillment of planned educational objectives. The results of research on the subject indicate that skill systems are components of intellectual abilities and conditions for the development of thinking. They acquire a didactic dimension in the teaching-learning process, and their assimilation requires pedagogical guidance (Sixto & Márquez, 2017).

Among the challenges of the teaching-educational process in Ecuador is ensuring that educators can adapt their pedagogical competencies to the realities of their students to improve the quality of education (Gómez et al., 2024). In this context, Barrera et al. (2017) highlighted that higher education institutions need to implement a teaching-learning system grounded in Problem-Based Learning (PBL) to develop interpretative, critical, and proactive skills in university students, enabling them to contribute to solving problems in their environment. Additionally, Project-Based Learning (PjBL) is emphasized as a means to further enhance these skills. With these approaches, graduating professionals will be able to become transformative agents of the reality in which they will practice their profession.

Currently, university students are skilled in the use of computer tools, making it possible to apply computational algorithms to identify strengths and weaknesses and address the latter through intelligent tutoring systems (Rodríguez, 2021). Among the many tools available today, ExeLearning stands out for its advantage as free software, allowing the creation of educational content without requiring advanced programming knowledge. Its effectiveness and acceptance by both students and educators have been demonstrated in various teaching-learning contexts (Silalahi, 2020; Vielsmeier et al., 2020; Bustos et al., 2022). Furthermore, the modern university aims not only to train competent professionals but also to equip them with the ability to transmit their knowledge, a goal where digital technology can be highly beneficial (León et al., 2022).

Based on these precedents, the need to develop pedagogical skills in university students is identified, even if they are not being trained as teachers. This is grounded in the importance of their ability to select useful content from the vast amount of information available, process it critically, and convey it within the environment where they will carry out their professional activities after graduation. Simultaneously, given modern trends in digital education, the skills young people acquire in using these technologies, and their preference for them, the possibility of employing technological tools as part of a didactic strategy for developing these skills is recognized.

This research aimed to design a didactic strategy based on ExeLearning to enhance pedagogical skills among students in the Biotechnology program at Ikiam Regional Amazonian University in Ecuador.

METHODOLOGY

This is a research article developed under the emerging paradigm, that prioritizes utility and the solution of practical problems with a mixed-methods approach (Hernández-Sampieri & Mendoza, 2018). The study was conducted at Ikiam Regional Amazonian University, located in the province of Napo, Ecuador, from July to October 2024.

First, a questionnaire was developed to diagnose students' pedagogical skills. It consisted of 10 questions related to their knowledge of the program, mastery of pedagogical skills, prior participation in teaching support activities, use of computer tools for learning, and willingness to engage in a strategy like the one intended to be designed. To validate the questionnaire, a group of experts was selected, comprising eight individuals (five men and three women), seven of whom hold Ph.D. degrees and one an MSc. All experts have at least 10 years of experience in university teaching across Ecuador, Mexico, Cuba, and Colombia. The experts were provided with an instrument containing questions about the questionnaire, evaluated on an ascending Likert scale from 1 to 7, with three unfavorable responses, one neutral, and three favorable (1 = not satisfied; 4 = neutral; 7 = very satisfied). The reliability of the instrument was determined by calculating Cronbach's alpha (Celina & Campo, 2005), and it was considered the validity criterion for applying the questionnaire to the students.

Once the instrument was validated, the diagnosis of pedagogical skills among the students was conducted. The participants were seventh-semester students in the Biotechnology Engineering program. The questionnaire was sent to the entire target population for the research (the 77 students enrolled in that semester), and 30 of them responded.

Consent was not explicitly requested from the participants in the research; instead, the submission of the completed questionnaire was considered as implicit consent to participate in the study. The results were processed while ensuring the anonymity of the participants.

Based on the diagnostic results, a strategy proposal aimed at developing pedagogical skills in the students was designed. Once developed, the strategy was sent to the experts for validation using the previously described methodology.

RESULTS AND DISCUSSION

DIAGNOSIS OF PEDAGOGICAL SKILLS IN STUDENTS

The Cronbach's alpha coefficient calculated from the experts' responses on the validity of the questionnaire was 0.77, which is considered a good consistency value and supported its use in the research. Of the 30 students (38.96% of the population) who responded to the questionnaire, 18 are women (60% of the sample). Sixteen students (53.3%) are aged between 18 and 22 years, 13 (43.3%) are aged between 23 and 27 years, and one student (3.3%) is in the age range of 28 to 32 years. The following are the key results derived from the questionnaire responses.

Ten percent of the participants (Figure 1) stated that they have no knowledge of teaching methodology, and 43% consider their knowledge to be limited. Thirty-seven percent fall into a medium level (neither much nor little), and the remaining 10% believe their knowledge of teaching methodology is sufficient.

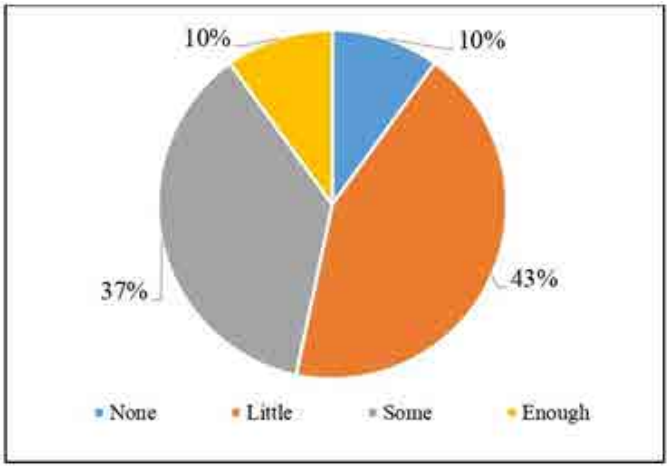

Figure 1: Knowledge about teaching methodology as reported by the students

It is known that there is an important subjective component in questionnaire responses (Li et al., 2021), so this result may include both underestimations and overestimations of students' self-assessments. For example, in Spain, Pizá & Suñé (2022), in a study on university students' self-perception of their own knowledge about Mathematics, demonstrated that at least one in three students is aware of their educational weaknesses, which shows that the subjective component does indeed play a significant role in these evaluations. Similar results had been obtained in Chile by Castro & Jaramillo (2018) in a study on the self-perception of pedagogy students regarding their vocation for teaching across various dimensions. However, the fact that more than half perceive themselves as poorly equipped to teach suggests the usefulness of a strategy to address this gap.

Despite this lack of knowledge, the students were able to identify four pedagogical skills: mastery of content, teamwork, communication skills, and innovation in learning methods (Figure 2).

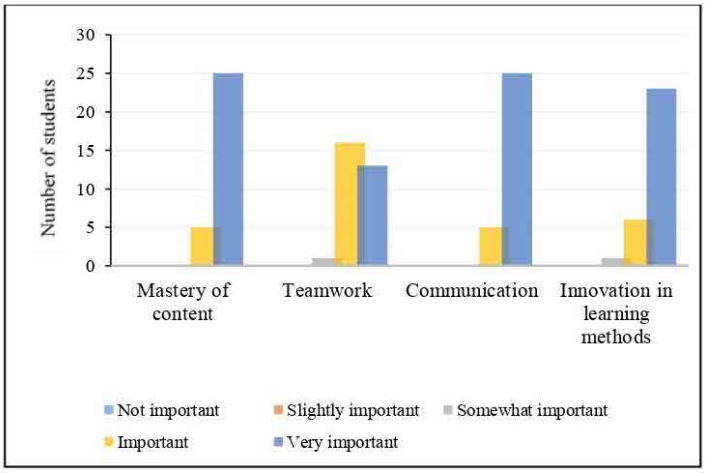

Figure 2: Pedagogical skills identified by the students

All participants considered that mastery of content and communication skills are important or very important pedagogical skills; the other two skills (teamwork and innovation in learning methods) were considered important or very important by 29 out of the 30 participants (96.6% of the sample).

Mastery of content can be enhanced through the use of digital resources that allow students to visualize study material and absorb information; among other digital resources, gamification of classes and the review of materials before class help students better understand the content and can be used for these purposes (Zainuddin, 2018).

Digital environments can also contribute to the development of communication skills (Claro et al., 2018). In fact, in modern universities, various resources are used to foster communication between students and professors. For example, it has been shown that messaging apps like WhatsApp can be conveniently used for this purpose due to their interactive capabilities between students, between professors and students, and through groups created for educational objectives (Morsidi et al., 2021).

Teamwork fosters interdisciplinary and multidisciplinary relationships between individuals specialized in different areas of knowledge. Through these relationships, individuals benefit from the knowledge and skills of others and can cooperate in achieving a common goal. For this reason, authors such as Rodríguez et al. (2021) highlight it as one of the skills that should be developed in future professionals. As in the previous cases, this is a skill that significantly benefits learning and can be developed using digital tools (Lorente et al., 2024).

The use of innovative learning methods, including technological tools, helps shift students' thinking and capture their attention (Kalyani & Rajasekaran, 2018). Innovative capacity is related to three fundamental elements of the future agent of social change: the ability to perceive failure as an opportunity for learning and new contributions to the outcome, critical thinking as a way to analyze mistakes and correct them, and the inherent feasibility of quick and efficient access to existing information on a topic through technologies such as e-learning (Rodríguez et al., 2021).

Ninety-three percent of the respondents considered the use of digital tools for learning to be useful or very useful (Figure 3), and consequently, 80% of the participants expressed that they would agree or strongly agree to participate in a strategy that uses ExeLearning to improve their pedagogical skills (Figure 4).

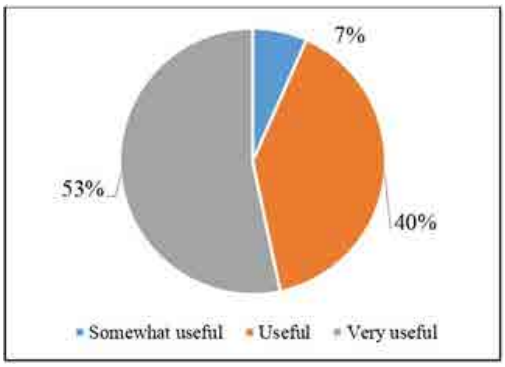

Figure 3: Opinions of the respondents on the usefulness of digital tools in learning

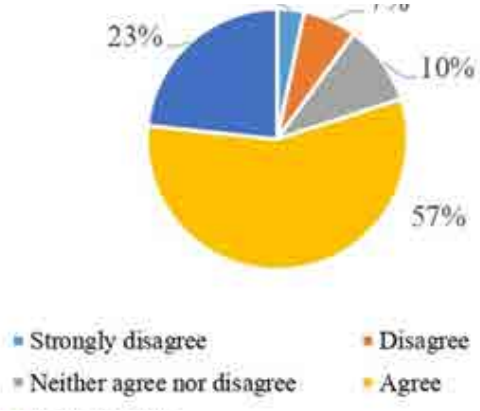

Figure 4: Willingness of the respondents to participate in a strategy based on ExeLearning of the development of the pedagogical skills

Today, many students prefer using virtual environments and software for learning; they even advocate for the existence of informal digital spaces where they can obtain various types of content. This has motivated the development of practices more centered on the student, their self-development, and independence in searching for and transmitting information through platforms and other resources of this kind (Valtonen et al., 2021). However, despite this identified need and the fact that these digital resources are already being used in practice for knowledge acquisition and skill development, insufficient theoretical work has been done to systematize their use (Häkkinen et al., 2016), which supports the use of strategies like the presented below.

Innovative pedagogical approaches, including problem-based learning, flipped classrooms and interactive teaching, enhance students' critical thinking. Technology-supported teaching practices significantly improve student performance, foster critical thinking, participation in activities, and collaboration. Unlike traditional methods that rely on the passive reception of knowledge by students, interactive methods through digital technology tend to develop the construction of knowledge, enhancing creativity and proactivity in future professionals (Bhuttah et al., 2024).

DESIGN OF THE DIDACTIC STRATEGY

Based on the results of the diagnosis, a didactic strategy supported on ExeLearning was designed for the acquisition of pedagogical skills by the students (Table 1). The strategy combines individual activity

procedures, such as observing audiovisual materials, completing questionnaires, and sharing personal opinions in forums, with group activities such as teacher-guided discussions and collective case analysis.

The general objective of the strategy is to develop pedagogical skills in seventh-semester students of the Biotechnology program through the use of the digital tool ExeLearning. It includes general and flexible activities to be carried out within the framework of the course "Plant Biotechnology," allowing educators to apply it within the objectives and content specific to the subject. The strategy aims at the development of three pedagogical skills with their corresponding specific objectives:

- Search, processing, and assimilation of information/ Facilitate the assimilation of relevant concepts.
- Logic and critical thinking / Explain new concepts (ExeLearning, logic, critical thinking).
- Communication/ Promote the development of efficient communication.

Table 1: Didactic strategy for the development of pedagogical skills

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General objective: To develop pedagogical skills in 7th-semester students of the Biotechnology program through the use of the digital tool ExeLearning						
Pedagogic skills	**Training estructure**					**Estimated time: 30 min**
	Specific objective	***Start***	***Development***		***Conclusion***	***Evaluation***
		Teaching resources	**ExeLearning**	**Instruments**	**Activity**	
Search, processing, and assimilation of information	Facilitate the assimilation of relevant concepts	Exploratory questions Open-ended questions focused on reflection about J. Piaget, the teaching-learning process, and biotechnology, for example: How does learning work?	Interactive activity Complete the concepts (fill-in-the blank questions) Multiple choice questions	Questionnaire Consisting of linking, closed, and multiple-choice questions	The facilitator explains to the students that they will be organized into groups to review the concepts covered and identify their applications in biotechnology.	Overview The students review the information shared at home and share their doubts with the facilitator.
Estimated time: 30 min						
Logic and critical thinking	Explain new concepts (ExeLearning, logic, critical thinking)	Guided discussion Participatory and informal debate on educational ICTs + ExeLearning	Illustrative Activity Graph interpretation (Apps, biotechnology, others) Illustrated diagram in ExeLearning (timeline)	Video Introductory videos: Critical thinking (Omar Fuentes) (Andres Oppenheimer)	After the introductory videos, the facilitator instructs the students to define basic concepts (logic, critical thinking, ExeLearning) and their characteristics.	Forum The students share their questions and comments in this space.
Estimated time: 30 min						
Communication	Promote the development of efficient communication	Introductory focal activity Share instrumental music in ExeLearning, listen to opinions, and link concepts (communication and music)	Non-interactive activity Public speaking videos (M. L. King) (Zach Morris)	Case studies Documents for the analysis of specific cases (group analysis)	The facilitator outlines the main points of the training (communication skills)	Interactive activity Complete the concepts (fill-in-the blank questions) Multiple choice questions

The abovementioned skills, recognized in the pedagogical field, are also common to contemporary university professions. Furthermore, in the context of professional training, it has become essential that graduates not only possess the specific competencies for their profession but also become agents of change (Celis, 2021). In the current context, marked by globalization and social networks, information is generated at great

speed, knowledge quickly becomes obsolete, and fake news spreads as easily or even more so than scientific findings (Celis, 2021).

This is because scientific results typically appear in peer-reviewed publications, while falsehoods can be found on numerous platforms. This situation drives leaders to develop skills such as selective information search and critical analysis to determine its usefulness, followed by its appropriate dissemination.

To achieve this, it is necessary for them to develop generic skills like those presented here. These are also referred to as "soft skills" or "21st-century skills," because they are not specific to the profession itself but enable individuals to identify useful content, analyze it critically, and transmit that information in changing environments (Rodríguez et al., 2021).

Under this approach, teaching is not limited to that provided in the classroom by professors dedicated specifically to this role; it is also carried out by professionals in research centers and scientific dissemination (FUNIBER, 2020). In fact, it is common to find university professors who take on part-time teaching after their work in science and production, and they do not always possess full mastery of these skills. The improvement of these generic skills would practically mean that every professional could become a potential teacher, providing them with the tools for successful performance in that role.

Finally, the development of these types of skills provides graduates with a more comprehensive education and greater opportunities for advancement in their new jobs. Currently, employers are looking not only for professional knowledge but also for the ability to communicate their knowledge to others and make decisions based on critical analysis of information.

Thus, it is even more crucial for educational institutions, especially universities that provide professionals to society, not to focus solely on preparing qualified graduates but also to enhance their personal skills, which are essential for productive performance in today's job market and necessary for interacting with others in this ever-changing environment (Ummatqul, 2020). These skills are sometimes underestimated by university professors and even by the graduates themselves (Dolce et al., 2019), which calls for greater attention.

In Ecuador, as noted by Bustos et al. (2022), more than 80% of teaching procedures and methods are traditional, meaning they focus on what the teacher explains and transmits, with students being passive recipients of that knowledge. This system, which Paulo Freire referred to as "banking education," must change if it is to integrate properly into the innovative models currently practiced worldwide. Although numerous studies address the importance of education, innovation,

and the competitiveness of graduates, all of which are included in the United Nations 2030 Agenda, research on the relationship between these elements is scarce (Barrichello et al., 2020). Nevertheless, there is little doubt about the influence education and its stakeholders can have on developing innovative skills and enabling graduates to enter the labor market as contributors to a new reality. One of the obstacles to this change is precisely the training of those who are meant to lead it: Herrera et al. (2021) conducted a survey of 1,864 teachers and observed that approximately half of them support a teaching-learning process based on collaborative methods for knowledge search, but the other half clings to traditional methods of knowledge transmission from the teachers' perspective and criteria. The need for a transformation is therefore very clear.

The evaluation of the proposed strategy by the experts resulted in a Cronbach's alpha coefficient of 0.82, which is considered a good consistency value. There is also the willingness of the students to participate, who are both actors and beneficiaries of the proposed model, as expressed in the results of the diagnosis conducted in the first phase of the study. Consequently, it is feasible to implement it under the conditions described in this research.

CONCLUSIONS

The diagnosis conducted in a group of seventh-semester students in the Biotechnology Engineering program at Ikiam Regional Amazonian University allowed the identification of weaknesses in the mastery of pedagogical skills that would be useful for their comprehensive professional training. It was also possible to establish that students are aware of the existence of generic pedagogical skills and their willingness to participate in a strategy supported by ExeLearning for their development.

Based on the identified weaknesses and literature references, a didactic strategy based on ExeLearning was developed to enhance the pedagogical skills of the students. Its satisfactory evaluation by a group of experts, along with the students' disposition to participate, support its implementation.

DECLARATION OF CONFLICT OF INTEREST: The authors declare that they have no conflicts of interest.

STATEMENT OF AUTHOR CONTRIBUTION AND ACKNOWLEDGEMENTS: Información disponible en la base de datos de la revista, que no se incluye en esta versión para evitar posibles conflictos de intereses con los evaluadores

DECLARATION OF APPROVAL OF THE ETHICS COMMITTEE: The authors declare that the research was approved by the Ethics Committee of the responsible institution, to the extent that it involved human beings.

DATA AVAILABILITY STATEMENT: The authors declare that the data used in the research performed are available without access restrictions for analysis by interested parties in the repository: https://zenodo.org/records/14268296

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