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Experimental spaces for the teaching of biology in university education

Espacios experimentales para la enseñanza de la biología en la educación universitaria

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Abstract

The study presents an analysis of the importance of experimental spaces in the teaching of biology in university classrooms, specifically in the Bachelor's Degree in Education, Biology emphasis, and Animal Production Engineering. The methodology used was quantitative in nature, with a descriptive type of research and a non-experimental cross-sectional design, involving a population of twenty (20) students. The technique employed was a survey, complemented by observation. The results revealed weaknesses in practical biology activities, particularly in field trips and experimental work. These findings suggested responses to real challenges in the biological field, through the development of skills using tactical elements that foster abilities in thinking, observation, analysis, integration, organization, creativity, decision-making, problem-solving, reflection, and evaluation. This was achieved through the planning of objectives, practical exercises, familiarization with phenomena, illustrative activities, concept learning, and research.

Keywords: Biology didactics, university education, experimental spaces, fieldwork, biology teaching.

Resumen

El estudio presenta un análisis sobre la importancia de los espacios experimentales en la enseñanza de la biología en las aulas universitarias, específicamente en la Licenciatura en Educación mención Biología e Ingeniería en Producción Animal. La metodología utilizada fue de enfoque cuantitativo, con una investigación de tipo descriptiva y un diseño no experimental de tipo transversal, en una población de veinte (20) estudiantes. La técnica empleada fue una encuesta, complementada con observación. Los resultados revelaron debilidades en la actividad práctica de biología, especialmente en las salidas de campo y el trabajo experimental. Estos hallazgos permitieron sugerir respuestas a los desafíos reales del campo biológico, a través del desarrollo de destrezas con elementos tácticos que fomenten habilidades de pensamiento, observación, análisis, integración, organización, creatividad, toma de decisiones, resolución de problemas, reflexión y evaluación, mediante la planeación de objetivos, ejercicios prácticos, familiarización con fenómenos, actividades ilustrativas, aprendizaje de conceptos e investigaciones.

Palabras clave: Didáctica de la biología, educación universitaria, espacios experimentales, trabajos de campo, enseñanza de la biología.

Introduction

University processes have evolved in response to emerging expectations and needs over time, adapting their methodologies to the changes that arise. A clear example of this evolution is biology, whose development has been significant since its popularization in the 19th century. The term "biology" was promoted by the French naturalist Jean-Baptiste Lamarck, who sought to integrate various disciplines related to the study of life forms. However, the foundations of biology date back to Aristotle's era, around 350 B.C., when the groundwork for studying living organisms was already laid.

As biology is a natural science dedicated to the study of life and associated phenomena, its teaching relies on a combination of theory and experimental applications, often materialized in laboratory practices. This ongoing evolution in the field requires constant adaptation of educational strategies to keep pace with scientific and technological advancements. Thus, the need to reconceptualize pedagogical methodologies in biology becomes essential, ensuring that education in this science adequately reflects current developments and prepares students to face contemporary challenges.

However, today, many universities face economic challenges that hinder the provision of suitable laboratories and spaces for practical biology teaching. In this context, it is crucial for educators to find ways to bring students closer to authentic scientific experiences through creative adaptations that simulate these learning environments. In this way, the loss of praxis in this fundamental area for understanding vital phenomena can be avoided.

Moreover, biology laboratories must be flexible in their use of biological materials and the application of experimental practices. Nowadays, various accessible and recyclable resources, adapted to the institution's environment, are employed to fulfill the empirical procedures necessary for student training. Therefore, experimental activity plays a crucial role in biology teaching, providing a solid theoretical foundation while developing practical skills and abilities, as noted by López & Tamayo (2012).

A fundamental strategy in biology, from a pedagogical perspective, is experimental work, which becomes a key tool when teaching biology and natural sciences in general. Its importance lies primarily in the ability to corroborate, in some cases simply and appropriately, many of the biological phenomena studied in theory. Additionally, it allows students to approach biology not from the abstractness of science but from a perspective focused on real and everyday experiences.

When students can engage in experimental activities, they not only confirm concepts but also construct their knowledge through action, a process that enables them to pose problems, enhance qualitative analyses, formulate hypotheses, design experiments in a planned manner, interpret results, rethink ideas, acquire multidisciplinary contributions in other fields of knowledge, and preserve scientific records, among other epistemological criteria in professional training, which they will later experience as educators if they enter the field of education, as described by Lorenzo (2020).

From this perspective, it is essential for practices to become indispensable elements for students, who will, in the future, become presenters of the experiences their training allowed them to live in order to face the challenges of the professional field, promoting a deeper and more lasting understanding of the principles. Therefore, it is established in both secondary and undergraduate education curricula to include theoretical and practical hours. However, this praxis implies a symbiosis of traditional didactic models, discovery-based, and constructivist approaches, with the latter giving it a sense of social construction, making it a flexible process in open spaces, as Guirado (2016) states.

According to Parada (2023), different paradigm shifts have promoted educational methodologies where the student is an active element with collaborative construction. The empirical process, as part of this shift, allows for the intertwining of didactic models with relevant strategies, aiming to achieve, at a minimum, the generic competencies of "skills that enable students to respond to the needs of the context in which they find themselves" (Pineda, 2021, p. 10). These are part of a compendium of didactic strategies at the upper secondary level with approaches to reality, searching, organizing, selecting information, discovery, extrapolation, transfer, problematization, creative divergent and lateral thinking processes with collaborative work, as noted by Caicedo *et al.* (2017).

It is now about approaching a space for practice from the epistemology involved in the empirical educational function, as this is where teachers contribute to reflective action on science, from pedagogical and meta-scientific thinking, within their role as observers, as Zorrilla et al. (2022) indicate. This is evoked as biology graduates, who are teachers, are called to venture into diverse spaces—natural conditions, origin, development, structure, heredity, and other aspects of plant and animal organisms. Hence, experimental activity is an inescapable aspect, though the problems and challenges of university situations in Venezuela are numerous, including the lack of laboratories in new areas or the need to equip existing ones:

> At present, it is not a metaphor to say that the infrastructure of our universities is falling apart, as the advanced state of deterioration and abandonment of university facilities by the authorities is undeniable. This is to the point where even classrooms do not meet the minimum conditions for the exercise of teaching functions (Leal, 2019, p. 1)

Considering the author's statement, it is evident that laboratories, sports facilities, cultural spaces, and production areas, among others, require new alternatives for their use as strategies, understanding that the university faces a complexity of different approaches that are not strictly budgetary but also involve other aspects. In this case, it is of interest to address teaching practice, where efforts must be directed towards new experiences that require adjustments in time, resources, didactic content, and even attitudes to give laboratories the place they demand in science learning.

In this context, the National Experimental University of the Western Plains "Ezequiel Zamora" (Unellez), as a university institution in the Llanos region, faces the challenge of revitalizing its learning spaces. Although the facilities lack fully equipped laboratories, the Education degree with a mention in Biology and the Animal Production Engineering program offer a variety of subprojects covering key areas of biology, such as general biology, ecology, biochemistry, genetics, microbiology, cell biology, plant biology, biotechnology, and animal biology.

These subprojects integrate both theoretical and practical content and represent a valuable experiential alternative for experimental learning. Despite current limitations, these efforts seek to make the most of available resources, adapting teaching methodologies to provide enriching experiences that compensate for the infrastructure and resource deficit and adequately prepare students to face challenges in the field of biology.

This article focuses on analyzing the importance of experimental spaces for teaching biology in university classrooms and the strategic direction that can be given through contextualized modules, as key elements in the educational field where there is a lack of laboratories. First, experimental spaces are highlighted as places dedicated to activities involving objects and phenomena, based on didactic dimensions, functioning, and indispensable resources. The foundation is based on the existence of curricula with biological subprojects in the Biology Education and Animal Production Engineering programs, where a lack of praxis is anticipated.

Secondly, the study of biology is addressed as a conceptual and empirical component that deals with living organisms and their characteristics, through experimental work involving elements such as objectives, exercises, familiarity with phenomena, illustrative activities, learning concepts, and investigations, as adapted from Leite and Figueroa's (2004) classification. They emphasize the accessibility of understanding theoretical explanations through practical work and the increasingly prominent presence of such work in university classrooms.

Finally, the need for teachers to adopt routes for experimentation is discussed. This can be achieved through the development of modules that can be used as experimental spaces, thus expanding the range of flexible options available in biology. "It is essential to conceive educational activities that are attractive and challenging for students" (Puche, 2024, p. 7). This is all grounded in operational work with dimensions quantified and reinforced by observation as a means to highlight student experiences in university classrooms, within the framework of discussion and result analysis.

Methodology

The research adopts a quantitative approach, in line with Hernández *et al.* (2014), using numerical and graphical measures to analyze relevant variables. This is a field study based on data collected directly from the real-world environment and is descriptive in nature, providing detailed interpretations of the observed phenomenon, according to Palella & Martins (2012). The methodological design is non-experimental, as per Hernández & Mendoza (2018), which means the objective is to analyze the state of a variable through description; it is also cross-sectional, allowing for the observation of phenomena in their natural context: Unellez, El Nula Extension, and the collection of data at a single point in time.

The census sample consists of 20 students from the Animal Production Engineering program and the Biology specialization in the Education degree, representing areas of biology with experimental activity. Data collection was carried out using a structured questionnaire with 25 items, focusing on variables such as experimental spaces and aspects of experimental work in biology. The questionnaire covers didactic, functional, and resource dimensions, with closed-ended questions for precise and detailed evaluation.

From the perspective outlined above, validation was carried out through content expert judgment. This means the measurement instrument designed for information collection was submitted for consideration and analysis by three experts with knowledge in the area of study and research methodology, to assess criteria such as relevance, coherence, clarity, dimension, and indicators, as well as proper wording.

It is important to highlight the use of processing techniques for information analysis at its initial logical stage, with bibliographic reviews of previous research related to the studied dimensions. The methodological phase allowed the structuring of the instrument to operate in terms of organizing, tabulating, and analyzing the data obtained through descriptive statistics. Therefore, the significance of experimental spaces is addressed by the logical connection found between the reality in university classrooms and the theoretical structures presented by some authors, alongside the empirical need in biology teaching.

Results

The following tables present the results of the dimensions and indicators in frequencies, percentages, and interpretations according to the emphasis of the structured items in the survey.

Table 1
Didactic dimension.

Indicator	Emphasis	Yes (%)	No (%)
Strategy	Use of experiments.	40	60
	Presence of field trips.	30	70
	Promotion of experimental work.	40	60
	Consideration of experiential learning.	80	20
	Strategies applied to acquire empirical knowledge.	55	45
Technique	Presence of experimental activities as a pedagogical technique.	35	65
Contents	Development of programmatic content in a theoretical-practical manner.	55	45

Source: Developed by the author (2024). Note: Information from the instrument applied to students.

The data in Table 1 shows significant variability in students' perceptions of the didactic dimension of their education. In terms of "strategy," only 40% of students believe that experimentation is used effectively in the teaching process, while 60% feel otherwise. The frequency of field trips is even lower, with only 30% of students reporting them, compared to 70% who do not. Additionally, the promotion of experimental work is also insufficient, with 60% of negative responses compared to 40% positive. However, 80% of students highly value the inclusion of experiential learning, contrasting with the 20% who do not consider it relevant. Regarding strategies for acquiring empirical knowledge, 55% of students acknowledge their use, while 45% do not.

In the "technique" category, only 35% of students report the inclusion of experimental activities as part of pedagogical techniques, while 65% do not observe them. Concerning the development of “content,” 55% of students believe that it is addressed through a theoretical-practical approach, compared to 45% who do not perceive it that way. These findings indicate an urgent need to strengthen the integration of experimental strategies and techniques into teaching, as well as to improve the implementation of experiential and practical activities in the curriculum. Addressing these areas could help align teaching with students' expectations and foster more meaningful and effective learning.

Table 2
Functionality and resources dimension

Indicator	Emphasis	Yes (%)	No (%)
Structure	Presence of an adequate structure for experimental activities.	0	100
Didactic materials	Availability of necessary materials for conducting biology practices.	0	100
	Need for physical space and materials to carry out experiments..	90	10
Human resources	Availability of specialized teachers in biology or natural sciences.	25	75
	Teachers respond assertively to experimentation.	85	15
Financial resources	Availability of financial resources for experimental activities.	0	100

Source: Developed by the author (2024). Note: Information from the instrument applied to students.

Table 2 shows the realities of the conditions of the "functionality and resources of experimental spaces" dimension. Regarding the "structure" indicator, 100% of students acknowledged the absence of adequate structures for experimental activities. The same occurred with the "didactic materials" indicator, where 100% of students perceived a lack of necessary materials for conducting biology practices. Additionally, 90% of students expressed the need for a physical space and materials to conduct experiments, while 10% did not see this as necessary.

For the "human talent" indicator, 25% of students noted the presence of biology or natural sciences specialist teachers, compared to 75% who did not observe this potential. These results highlight a significant deficiency in human resources, which is crucial for making experimental spaces functional. Among the few existing teachers with this specialty, 85% were positively rated for their effectiveness in experimental activities, according to the students, while 15% lacked this skill set in biology. As for the "financial resources" indicator, all students (100%) reported the absence of financial resources for experimental activities.

These findings reveal a lack of didactic materials, human talent, and financial resources, which undoubtedly exceed the influence of individual teachers to resolve. However, exploring alternatives in different contexts is the closest approach to integrating direct contact with experimentation, aiming to reconceptualize learning through solutions adapted to the institutional context.

Table 3
Experimental work dimension

Indicator	Emphasis	Yes (%)	No (%)
Objectives	Experimental work contributes to achieving objectives.	100	0
Exercises	The development of experimental exercises allows for understanding the proper use of laboratory implements and equipment.	90	10
	Integration of activities with the exercise of experimental work.	40	60
Familiarization with phenomena	Familiarization with important biological phenomena.	45	55
	Replication of experiments by biologists to become familiar with their experiences.	35	65
Illustrative activities	Presence of illustrative activities to explain experimental work.	40	60
	Illustrative activities help in acquiring knowledge.	100	0
Learning concepts	Experimental work contributes to the significance of concepts.	100	0
	Learning concepts strengthens vocabulary in biology.	85	15
Research	Experience with some experimental study of a biological phenomenon.	0	100
	Research contributes to self-learning.	65	35
	Conducting research as part of content development.	45	55

Source: Developed by the author (2023). Note: Information from the instrument applied to students.

Table 3 highlights the results of the "experimental work" dimension. For the "objectives" indicator, 100% of students affirmed that experimental work contributes to achieving specific goals, demonstrating the connection between these practices and essential objectives guiding such actions. Following this, the "exercises" indicator showed that 90% of students believed this work aids in the proper use of laboratory equipment, while 10% disagreed. This is directly related to the low percentage of engagement in exercises involving phenomena, with only 40% confirming their participation, compared to 60% who did not perceive this integration in the teaching process.

The "familiarization with phenomena" indicator revealed that 45% of students felt familiar with important biological phenomena, whereas 55% did not observe this practical potential. Furthermore, the lack of repeated experiments to gain familiarity with these experiences is significant, with only 35% engaging in such practices, while 65% did not. Regarding "illustrative activities," 40% of students recognized the presence of such activities for explaining experimental work, contrasted by 60% who did not. However, 100% of students considered these illustrative activities as helpful in acquiring knowledge.

Concerning the "concept learning" indicator, all students (100%) acknowledged that illustrative activities contribute to acquiring knowledge in experimental practices. Additionally, 85% viewed this learning as a strength in building biological vocabulary, compared to 15% who disagreed.

Lastly, the table reflects the "research" indicator, where 100% of students admitted not conducting biological research to resolve issues, especially in environments like the university, where there is a shift from pedagogical to andragogical processes. Moreover, 65% of students believed research contributes to self-learning, while 35% did not. This aligns with the low occurrence of research as part of content development, with 55% acknowledging its presence and 45% affirming that research plays a fundamental role in professional training.

These data reveal low levels of empirical skills, where students miss opportunities to connect theoretical and illustrative content through problem-solving, research, and authentic inquiry.

Next, as an annex to the indicators specified above, a table is presented detailing specific modules suggested for planning experimental spaces, emphasizing contextualized approaches:

Table 4
Suggested Modules as Routes for Experimentation

Modules	Emphasis
Curriculum study for teachers to design experimentation routes.	Identify within the curricula of the Bachelor's programs in Biology and Animal Production Engineering the subprojects with biological applications, so that teachers can outline viable spaces for experimentation in subprojects such as General Biology, Cellular Biology, Plant Biology, Animal Biology, Biochemistry, Ecology, Genetics, and Microbiology.
Experimentation work in natural environments.	Hikes, field explorations, direct observations, construction of insectaries or other types of biological samples.
Experimentation in local processing companies.	Guided tours, direct observations, handling of raw material processing equipment (water, dairy, meat...), extraction of biological samples, and connection with public and private entities related to hygiene and food handling.
Experimentation work with household items.	Homemade experiments, direct observation of illustrations, videos, consultations of digital materials.
Experimentation work under the microscope, in external environments.	Case studies, requests for permission to access nearby environments with microscopes, direct observations in clinical and animal medicine laboratories, collection of biological samples.

Source: Developed by the author (2024).

Table 4 shows the results of suggested modules for practical activities, involving the creation of routes that integrate natural spaces and industries processing raw materials, such as meat, dairy, water treatment, and food production, among others. Additionally, it emphasizes the use of household or everyday materials to represent biological processes, leveraging the resources available within the university's institutional environment. For more complex biological processes, the need arises to collaborate with other facilities, such as educational, analytical, or veterinary medicine laboratories, as these environments are essential for developing specific content. The invitation is undoubtedly to seek social elements to integrate into experimental activities, both within and outside the institution.

Discussion

The results reveal that a significant majority of students identify weaknesses in the practical biology activities, particularly in the use of experiments, field trips, and experimental work. These deficiencies are largely attributed to the lack of adequate infrastructure, didactic materials, reagents, financial resources, and specialized biology personnel. This finding underscores the dependence of experimental practice on both academic infrastructure and the availability of material and human resources, as noted by Muschietti *et al.* (2017).

Furthermore, the limited planning of didactic elements for biology practice reflects a deficiency in techniques, strategies, and content. The selection of these elements should not be rigid but adaptable based on the teacher's knowledge, conceptions, and values, as argued by Bermúdez & Ocelli (2020). The lack of systematic planning and adequate resources reinforces the insufficiencies observed in experimental practice. The role of the teacher involves adapting content to the social, ecological, and cultural realities of the students, responding to an educational context, as outlined by Aragón & Cabarcas (2023).

Experimental activity must go beyond merely transmitting curricular content for the teaching-learning process in science due to its theoretical foundation and contribution to skill and competence development, according to Gener *et al.* (2022). It is crucial that experimental practice is not limited to demonstrating phenomena but rather facilitates experiences that connect concepts to problem-solving. This involves creating new learning contexts, utilizing experiential elements, and even digital devices to rethink experimentation through the lens of nature and society.

The factors associated with studying biology through experimental work, such as objectives, exercises, familiarization with phenomena, illustrative activities, and concept learning, are present but in minimal conditions. These elements should be promoted in teaching practice to strengthen procedural and conceptual learning, using sensory and instructional processes to test and contrast results. Zorrilla *et al.* (2022) highlight the importance of this approach in improving experimental activity.

The construction of knowledge in experimental spaces should be based on problem-posing questions that challenge the information obtained by confronting it with prior knowledge. Research suggests that this approach is key to problem-solving, allowing students to formulate strategies and methodologies grounded in result validation and procedure reformulation, thereby bringing them closer to scientific practice. The teacher's proposal should involve teaching through the representation of disciplinary content as a technique, skill, or attitude, within the context of educational processes (Lorenzo, 2020).

Finally, considering the scenarios proposed as routes for experimentation, we can refer to Puche's (2024) criteria: the inclusion of contextualized learning with content that connects with students' realities and experiences creates a link to their immediate environment and everyday life. This fosters a deeper and more meaningful understanding of the topics discussed.

Conclusions

It is concluded that experimental spaces are vital because they establish a connection between didactics, resources, and teaching plans. Therefore, in natural sciences like biology, the combination of strategies with traditional models, discovery-based learning, and constructivist approaches allows educators to explore student potential beyond the mere integration of unilateral content.

In response to the study of biology from both a conceptual and empirical perspective, the presence of experimental spaces in university classrooms revealed that having a specialist teacher in the area is essential. A teacher who comprehensively understands the subject matter can clearly discern the flexibility or inflexibility of biological phenomena in contextualized spaces. This is particularly important because complex biological processes often require specific conditions for their management.

It was found that teachers strive to relate experimental pedagogies with theoretical foundations. However, the lack of resources and insufficient planning systems in terms of strategies and techniques in biological subprojects results in theory dominating over practice in the development of programmatic content. Additionally, students have limited connection with activities that develop skills, procedural knowledge, and conceptual learning, particularly in relation to familiarization, illustration, and scientific methodologies when studying biological phenomena.

In terms of establishing functional areas within experimental spaces, external vectors were mapped, highlighting the institution's potential through the study of modules aimed at fostering a marked exponential curve in the acquisition of practical knowledge. There should be an inclusion of natural and social environments to open up practices through alternative routes. The idea stems from an invitation extended to biology teachers to make experimental spaces a cornerstone in shaping the graduate profile.

Indeed, the importance of experimental work in the education of undergraduate students in the Bachelor's Degree in Education with a specialization in Biology or in Animal Production Engineering lies in the fact that practical activities develop skills that allow students to perceive tactical elements that enhance their abilities in thinking, observation, analysis, integration, organization, creativity, decision-making, problem-solving, reflection, and evaluation. This makes experimental work a necessary activity for those training to become future professionals, particularly in the educational environment, enabling them to transcend the cognitive idea of experimentation into countless other environments.

References

Aragón, R. L. A. & Cabarcas, B. K. (2023). Entorno social vivencial de los estudiantes y la contextualización de los contenidos para el aprendizaje de la Química. *Revista Latinoamericana*

Ogmios, 3(7), 1–13. https://doi.org/10.53595/rlo.v3.i7.059.

Bermúdez, G. M. A. & Occelli M. (2020). Enfoques para la enseñanza de la biología: Una mirada para los contenidos; Universidad de Valencia. Departamento de Didáctica de las Ciencias Experimentales y Sociales. *Didáctica de las Ciencias Experimentales y Sociales*, (39), 135-148. https://ri.conicet.gov.ar/handle/11336/138931

Caicedo, P. L., Valverde, M, L. & Estupiñán, N. I. (2017). *Estrategias didácticas para la enseñanza* de biología y química en la enseñanza media. *Polo del Conocimiento*, 2(5), 1175-1186. doi:https://doi.org/10.23857/pc.v2i5.205

Gener, C. J., Armiñana, G. R., Piclín, M. J., Gasca, C, D. A., Fimia, D. R., De La Cruz, T. J. A., Gonzales, G.L. A. & Iannacone, O. J. (2023). El proceso de enseñanza-aprendizaje de la práctica de campo en la formación inicial del profesor de biología. *Paideia XXI*, 12(1), 79–105. https://doi.org/10.31381/paideia.v12i1.4839

Giraldo, M. J. A. (2016). *El experimento en la enseñanza de la biología. Un estudio de caso con licenciados en biología de tres instituciones educativas distritales.* [Tesis de licenciatura, Universidad Pedagógica Nacional, Bogotá, Colombia] Repositorio de la UPN. http://repository.pedagogica.edu.co/handle/20.500.12209/1745

Hernández, S. R., Fernández, C. L & Baptista, P. (2014). *Metodología de la Investigación.* Sexta edición. Editorial Mc Graw Hill.

Hernández, S. R. y Mendoza, C. (2018). *Metodología de la Investigación: Las rutas cuantitativas, cualitativas y mixtas.* McGraw-Hill Interamericana.

Leal, A. (2019, 23 Febrero). Problemas y desafíos de la situación universitaria en Venezuela. *Otras voces en educación.* http://otrasvoceseneducacion.org/archivos/302266

Leite, L. & Figueroa, A. (2004). Las actividades de laboratorio y la explicación científica en los manuales escolares de ciencias. *Alambique*, 39, 20-30.

López, R. A. M. & Tamayo, A. O. E. (2012). Las prácticas de laboratorio en la enseñanza de las Ciencias Naturales. *Latinoamericana de Estudios Educativos*, 8(1), 145–166. https://revistasojs.ucaldas.edu.co/index.php/latinoamericana/article/view/5036

Lorenzo, M. (2020). Revisando los trabajos experimentales en la enseñanza universitaria. Universidad Nacional del Litoral. Facultad de Bioquímica y Ciencias Biológicas. Gabinete Pedagógico. *Aula Universitaria*, (21), 15-34. https://ri.conicet.gov.ar/handle/11336/170694

Maturana, C. O. Y. (2022). Integración Teoría y Práctica desde el Enfoque de Aprendizaje por Descubrimiento en la asignatura Biología Molecular del programa de Licenciatura en Biología y Química de la Universidad Tecnológica del Chocó Diego Luis Córdoba. *Revista Latinoamericana de Educación Científica, Crítica y Emancipadora*, 1(1), 441–459. https://revistaladecin.com/index.php/LadECiN/article/view/1

Muschietti, P. M. del P., Civeira, G. & Muschietti, P. M. (2017). La intervención docente en educación universitaria: una experiencia con prácticas de laboratorio para estudiantes de ciencias ambientales. *Revista de Educación en Biología*, 20(2), (pp. 28–40). https://doi.org/10.59524/2344-9225.v20.n2.22513

Palella, S. S. & Martins, P. F. (2012). *Metodología de la investigación cuantitativa.* Tercera edición. Editorial FEDUPEL.

Parada, O. A. (2023). Reflexiones para una nueva enseñanza ciudadana a partir de la Biología Cultural de Humberto Maturana. *Revista Estudios En Educación*, 6(10), 82-98. http://ojs.umc.cl/index.php/estudioseneducacion/article/view/289

Pineda, R. E. (2021). Estrategias didácticas constructivistas para el desarrollo de competencias genéricas en la asignatura de Biología del Nivel Medio Superior. *Revista Electrónica Sobre Tecnología, Educación Y Sociedad*, 8(15). https://ctes.org.mx/index.php/ctes/article/view/739

Puche, V. D. J. (2024). Metodologías educativas desde la teoría del conocimiento de Maturana y Varela para enseñanza de las ciencias naturales. *Revista Digital de Investigación y Postgrado*, 5(10), 59-81. https://doi.org/10.59654/z4qpj721

Zorrilla, E., Mazzitelli, C., Calle, R. A., Angulo, D. F. & Soto, L. C. A. (2022). Representaciones sociales sobre las prácticas de laboratorio: implicaciones epistemológicas y prácticas para la formación inicial de docentes. *Tecné, Episteme y Didaxis: TED*, (52), 101-116. https://doi.org/10.17227/ted.num52-13392