Revista Digital de Investigación y Postgrado
ISSN: 2665-038X
ISSN-L: 2665-038X
omar.escalona@iesip.edu.ve
Instituto de Estudios Superiores de Investigación Y Postgrado
República Bolivariana de Venezuela

Sánchez Molina, Carmen Eloísa

Competencias científicas e investigativas estudiantiles desde una perspectiva interdisciplinaria en la educación media general

Revista Digital de Investigación y Postgrado, vol. 6, no. 12, 2025, July-December, pp. 27-28
Instituto de Estudios Superiores de Investigación Y Postgrado
San Cristóbal, República Bolivariana de Venezuela

DOI: https://doi.org/10.59654/tgpqg354

Scientific and research competencies of students from an interdisciplinary perspective in general secondary education

Competencias científicas e investigativas estudiantiles desde una perspectiva interdisciplinaria en la educación media general

Carmen Eloísa Sánchez Molina
https://orcid.org/0000-0001-9564-2768
Santa Bárbara, Barinas state / Venezuela

Received: may / 5 / 2025 **Accepted:** may / 20 / 2025

How to citer: Sánchez, M. C. E. (2025). Scientific and research competencies of students from an interdisciplinary perspective in general secondary education. *Revista Digital de Investigación y Postgrado*, 6(12), 27-47. https://doi.org/10.59654/tgpqg354

* Doctor of Education, Master in University Teaching with a mention in Education, Universidad Nacional Experimental de los Llanos Occidentales Ezequiel Zamora. Barinas, Barinas – Venezuela. Tenured Lecturer, assistant category. Universidad Nacional Experimental de los Llanos Occidentales Ezequiel Zamora. Santa Bárbara de Barinas – Venezuela. Email: carmenisajose@gmail.comVenezuela.

Abstract

This paper analyzes the development of scientific and research competencies in General Secondary Education students from an interdisciplinary perspective, aiming to construct a theoretical approach focused on students' integral development. The study follows a qualitative methodology, using the hermeneutic method and grounded theory, and is based on in-depth interviews with natural science teachers from institutions in Santa Bárbara de Barinas. Findings reveal that interdisciplinary approaches foster critical thinking skills in students. Data analysis produced 44 emerging codes and two axial categories, enabling the construction of new theoretical concepts. The conclusions emphasize the need to strengthen these competencies within the Venezuelan educational context, aligned with national policies. This study presents an innovative contribution to educational and scientific advancement, seeking to improve teaching quality and promote the country's scientific and technological independence.

Keywords: Scientific competencies, Secondary Education, Natural Sciences, Venezuela.

Resumen

El documento analiza el desarrollo de competencias científicas e investigativas en estudiantes de Educación Media General desde un enfoque interdisciplinario, con el propósito de construir una aproximación teórica orientada al desarrollo integral del estudiante. La investigación es cualitativa, basada en el método hermenéutico y la teoría fundamentada, y se apoya en entrevistas en profundidad a docentes de ciencias naturales en instituciones de Santa Bárbara de Barinas. Los hallazgos evidencian que la interdisciplinariedad impulsa habilidades críticas en los estudiantes. El análisis generó 44 códigos emergentes y dos categorías axiales, lo cual permitió formular nuevos conceptos teóricos. Las conclusiones destacan la necesidad de fortalecer estas competencias dentro del contexto educativo venezolano, en consonancia con las políticas nacionales. Este estudio representa un aporte innovador al avance educativo y científico, con miras a mejorar la calidad de la enseñanza y promover la independencia científica y tecnológica del país.

Palabras clave: Competencias científicas, Educación Media General, Ciencias Naturales, Venezuela.

Introduction

In the contemporary educational landscape, marked by rapid scientific, technological, and social transformations, it has become imperative to rethink teaching-learning models in the natural sciences area. Science education faces the historical challenge of training citizens capable of understanding the complexity of today's world and actively participating in solving relevant socio-scientific problems (Pozo & Gómez, 2010). This challenge acquires special relevance at the General Secondary Education level, where the foundations for the development of scientific thinking are laid and fundamental attitudes toward science and its method are shaped (Ministerio del Poder Popular para la Educación, MPPE 2017).

The concept of scientific and investigative competencies has emerged as a central axis in this educational debate. According to Gamboa et al. (2020), these competencies represent an integrated set of knowledge, skills, attitudes, and values that enable students to address scientific problems with methodological rigor, creativity, and critical thinking. However, as demonstrated by Arias' (2017) studies in the Venezuelan context, there is a marked gap between this educational ideal and the predominant pedagogical practices in classrooms, which frequently reduce science teaching to the transmission of decontextualized conceptual content.

The described situation reflects what Freire (2012) called "banking education," a model that conceives students as mere passive recipients of information rather than active protagonists of their learning process. This criticism becomes particularly relevant when analyzing, as Sánchez and Herrera (2019) have done, the actual conditions under which science teaching develops in many Venezuelan institutions: insufficiently equipped laboratories, teachers with limited opportunities for pedagogical updating, and assessments that prioritize rote memorization over deep understanding and knowledge application.

The Venezuelan Natural Sciences curriculum for Secondary Education (MPPE, 2017) formally establishes the need for an interdisciplinary approach integrating perspectives from Biology, Chemistry, Physics, and Earth Sciences. Nevertheless, as revealed by Arias' (2017) research, this interdisciplinarity rarely materializes in classroom practices, where fragmented knowledge organization and scarce articulation between different scientific areas persist. This curricular dissociation has significant consequences for student training, limiting their ability to address complex problems that, by their nature, require integrative approaches from multiple disciplines.

In this context, developing scientific and investigative competencies from an interdisciplinary perspective emerges as a promising pedagogical alternative. As Gamboa et al. (2020) argue, this approach allows overcoming the artificial division between scientific disciplines and connecting school learning with real problems from social and environmental contexts. Along these lines, Herrera's (2016) work in Spain has demonstrated how didactic strategies based on scientific inquiry can significantly transform educational practices, fostering students' critical thinking skills, collaborative work, and creative problem-solving.

International experience offers valuable lessons for the Venezuelan context. Figueroa's (2017) studies in Peru have evidenced the positive impact of active methodologies on developing investigative competencies, while Lupión and Martín's (2016) research highlights the importance of linking scientific learning with global challenges like climate change or environmental sustainability. These contributions agree on the need to transcend traditional teaching models, promoting instead pedagogies that stimulate scientific curiosity, grounded questioning, and collaborative knowledge construction.

At the regional level, research such as that by in Colombia and Barón (2019) in Panama has provided significant evidence about factors that either favor or hinder the development of scientific competencies in secondary education students. These studies coincide in highlighting the crucial role of teacher training, availability of adequate resources, and implementation of evaluation strategies consistent with the objectives of contemporary science education.

In this line of thought, the present study aims to contribute to this educational debate from a theoretical-practical perspective, articulating conceptual foundations about scientific competencies (Gamboa et al., 2020; Pozo & Gómez, 2010) with critical analysis of relevant pedagogical experiences in the Ibero-American context (Herrera, 2016; Figueroa, 2017; Sánchez & Herrera, 2019).

Methodologically, the research combines: (a) A comprehensive documentary analysis of Venezuelan curricular frameworks (MPPE, 2017) in dialogue with the most advanced theoretical proposals in science didactics. (b) Systematic review of innovative pedagogical experiences developed in contexts similar to Venezuela's. (c) A field study in educational institutions of the Ezequiel Zamora municipality that allows contrasting theoretical references with classroom realities.

The results of this research seek to provide concrete elements to overcome the limitations identified by Arias (2017) and Sánchez and Herrera (2019). The relevance of this study transcends the academic sphere, since as Freire (2012) points out, quality science education is a fundamental right and a necessary condition for the full development of citizenship in democratic societies

Theoretical foundations

The development of scientific and research competencies in General Secondary Education requires a solid theoretical framework that integrates psychological, pedagogical, and sociocultural perspectives. The authors cited in this article provide essential foundations for understanding how these competencies are constructed and how they can be fostered through an interdisciplinary approach. Below are the main theoretical references organized into three key axes:

Conceptual foundations of competencies

The concept of *competency* is polysemic and has been approached from various disciplines. From the perspective of cultural psychology, Vygotsky (1985) emphasizes that competencies are situated actions, mediated by social interaction and context. This view highlights the social nature of learning, where knowledge is collectively constructed. Complementarily, Chomsky (1970) introduces the notion of *linguistic competence* as an innate mental structure, while Hymes (1996) expands this perspective by incorporating *communicative competence*, which considers language use in specific social contexts.

In the educational field, authors such as Tobón (2006a, 2006b) and Perrenoud (1999) have contributed to defining competencies as integrated capacities that combine knowledge, skills, and attitudes to solve problems in real contexts. These ideas have influenced curricular reforms in Latin America, such as in Colombia (Law 30 of 1992) and Peru (National Curriculum of Basic Education), where competencies have been incorporated as the central axis of student training.

Teaching-learning models in natural sciences

Science didactics has evolved from traditional models toward more active and constructivist approaches. Freire (2012) criticizes the "*banking*" *model*, where the student is a mere passive recipient of knowledge, and advocates for a liberating education that fosters critical thinking. In contrast, the *discovery model* (Bruner, 1968) and the *inquiry model* (Gil, 1993) promote students' construction of knowledge through exploration and authentic problem-solving.

Ausubel (1983) highlights the importance of *meaningful learning*, where new knowledge integrates with prior knowledge, while Piaget (1968a, 1968b) and Vygotsky (2009) provide key insights from constructivism. Piaget emphasizes cognitive development through stages (particularly *formal operations* in adolescents), whereas Vygotsky introduces the *Zone of Proximal Development (ZPD)*, where the teacher acts as a mediator to enhance emerging skills.

Interdisciplinary perspective and scientific competencies

Interdisciplinarity emerges as a key approach to developing scientific and investigative competencies. Gamboa et al. (2020) define these competencies as the ability to observe, question, design experiments, and communicate findings, linking scientific knowledge to relevant socio-environmental problems. This vision aligns with successful experiences documented by Herrera (2016) in Spain and Figueroa (2017) in Peru, where strategies such as *project-based learning* and *guided inquiry* proved effective.

The Venezuelan curriculum (MPPE, 2017) theoretically promotes this approach, though its implementation faces challenges, such as passive methodologies and a lack of resources (Arias, 2017; Sánchez & Herrera, 2019). To overcome these limitations, integrating the following didactic strategies is proposed: *(a) Pre-instructional:* Activation of prior knowledge (Díaz & Hernández, 2004). *(b) Co-instructional:* Cooperative learning and problem-solving (Frola & Velásquez, 2011). *(c) Post-instructional:* Portfolios and self-assessment to reinforce learning.

Methodology

The study adopted a qualitative approach (also referred to as phenomenological, interpretive, or naturalistic), focused on understanding the perspectives and experiences of secondary education teachers in the Natural Sciences field (Rojas de Escalona, 2010; Galeano, 2020). This approach allowed for the analysis of the participants' subjective and intersubjective realities, emphasizing the description and interpretation of the phenomenon within its natural context.

The hermeneutic method was employed, facilitating an in-depth interpretation of teachers' discourses through the hermeneutic circle (Martínez, 2012; Gadamer, 1984). This process involves constant dialogue between the parts (interviews) and the whole (educational context), enabling a holistic understanding of scientific and investigative competencies.

Additionally, grounded theory (Charmaz, 2013) was integrated to analyze actions and meanings through: *(a) Open coding:* Identification of emerging categories from the data. *(b) Axial coding:* Establishing relationships between categories to build an interpretive framework. *(c) Theoretical sampling:* Iterative selection of participants until theoretical saturation was reached.

Regarding the setting and participants, the research was conducted in five educational institutions in Santa Bárbara de Barinas (Venezuela), selected for accessibility and diversity (public/private). The key informants were five Natural Science teachers with: (a) Training in Biology, Chemistry, or related fields. (b) A minimum of five years of teaching experience. (c) Specialization or master's degrees.

The data collection technique used was in-depth interviews (Hurtado de Barrera, 2012) as the primary method, following a flexible thematic guide that addressed: (a) Perceptions of scientific competencies. (b) Applied didactic strategies. (c) Challenges in interdisciplinary teaching. The interviews recorded not only verbal responses but also nonverbal elements (tone, gestures), enriching the analysis.

It is worth noting that regarding data analysis techniques, the guidelines of Martínez (2007) and Strauss and Corbin (2002) were taken into consideration. The following were implemented: *(a) Categorization:* Coding of speech acts into themes. *(b) Structuring:* Organization of data through tables and semantic networks. *(c) Contrasting:* Comparison of findings with theoretical frameworks. *(d) Theorization:* Construction of an interpretative model on scientific competencies from an interdisciplinary perspective.

To ensure methodological rigor and guarantee validity and reliability, the following was applied: *(a) Triangulation*, comparing interview data with scientific literature. *(b) Theoretical saturation*, verifying that new data did not generate additional categories. *(c) Reflexivity*, with explicit acknowledgment by the researcher regarding their interpretive role to minimize biases. It should also be noted that the following ethical considerations were taken into account: (a) Informed consent from participants. (b) Anonymity in the use of data.

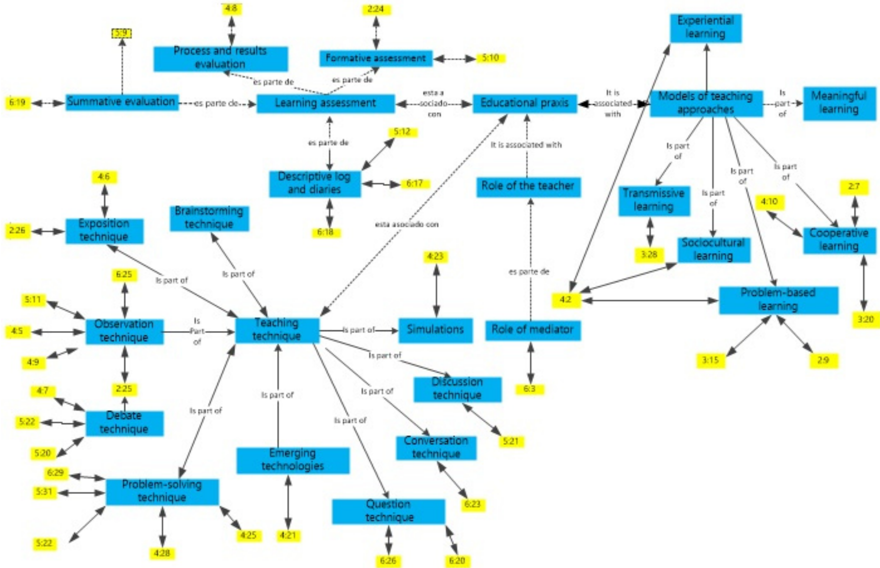
Results and discussion

In this context, the hermeneutic unit corresponding to the data consisted of five (5) documents containing the analysis information. The data were distributed across a total of 41 codes, assigned as follows: (a) 27 Codes in primary document 1. (b) 29 Codes in primary document 2. (c) 32 Codes in primary document 3. (d) 27 Codes in primary document 4. (e) 29 Codes in primary document 5.

The dynamic analysis categories emerged as the interview analysis progressed, allowing each code to be carefully examined, leading to the creation of two axial categories (see following figures).

Figure 1

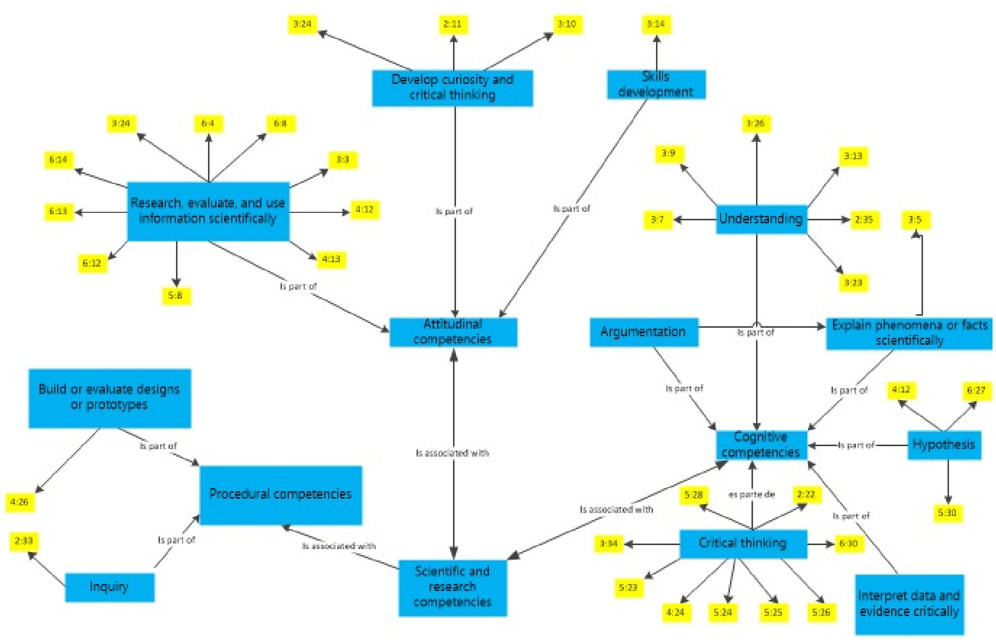
Semantic network of teaching models or approaches.



Source: Sánchez (2025). Prepared based on the analysis of interview results.

Figure 2

Semantic network of scientific and research competencies



Source: Sánchez (2025). Prepared based on the analysis of interview results.

The methodological triangulation applied in this study integrated three key dimensions to validate the findings: *(a) Empirical data (*teacher interviews). *(b) Theoretical framework* (specialized authors). *(c) Researcher's interpretation*. Below is a brief synthesis of the contrastive analysis of emerging categories, illustrated with the most relevant open codes. In the original research, this aspect spans nearly a hundred pages:

1. Problem-Based Learning (PBL)
    - Teachers: "Problem-based projects let us see real-world applications of science" (Inf. 1). "Students solve community issues, like water pollution" (Inf. 2).
    - Theory: "Active methodology focused on authentic problems that integrates disciplines" (Marra et al., 2014, p. 221). "Develops competencies such as argumentation and teamwork" (Rivera de Parada, 2007, p. 105).
    - Researcher: PBL demonstrates high effectiveness by linking learning to relevant social problems, though it requires additional resources and teacher training for full implementation.

2. Collaborative Learning
    - Teachers: "Group activities are essential for scientific projects" (Inf. 1). "Teamwork improves research skills" (Inf. 4).
    - Theory: Collective process with positive interdependence (Johnson et al., 1994). "Generates mechanisms for meaningful learning" (Vaillant y Manso, 2019, p.23).
    - Researcher: Collaboration replicates real scientific work, but requires teacher guidance to prevent unequal contributions.

3. Experiential Learning
    - Teachers: "Educational games create memorable learning" (Inf. 3). "Field practices are irreplaceable" (Inf. 4).
    - Theory: Knowledge is created through transformation of experiences (Instituto Tecnológico de Monterrey, 2010b). Links real contexts with learning (Samper y Ramírez, 2014).
    - Researcher: Although costly, experiential learning yields the most lasting results in scientific competencies.

4. Meaningful Learning
    - Teachers: "We connect theory with everyday phenomena" (Inf. 1). "We start from the known to explore the new" (Inf. 3).
    - Theory: "Requires relating new knowledge to existing cognitive structure" (Moreira, 2017, p.2). Process of meaning attribution (Latorre, 2017).
    - Researcher: The connection with personal experiences is the most effective bridge for scientific learning.

5. Constructivism
    - Teachers: "Students construct knowledge through projects" (Inf.1, 2, 3).

- **Theory:** "*Active reconstruction of meanings*" (*Coll et al., 1999, p.9*). "*Process of personal elaboration*" (*Porlán, 2002, p.19*).
- **Researcher:** Constructivism requires highly trained teachers to properly guide the process.

6. Deep Understanding
- **Teachers:** "We aim for them to apply concepts in new contexts" (Inf. 1). "Practical demonstrations improve understanding" (Inf. 2).
- **Theory:** "Ability to use knowledge creatively" (Otálora, 2009, p.123). "Knowledge transferability" (Gardner, 2000).
- **Researcher:** True understanding is evidenced in innovative application of concepts.

7. Developing Curiosity and Critical Thinking
- **Teachers:** "Researchable questions are our starting point" (Inf. 1). "The laboratory fosters questioning" (Inf. 2).
- **Theory:** Curiosity as learning engine (United Nations). Critical thinking as antidote to misinformation (Thrive Teaching, 2024).
- **Researcher:** These competencies form the foundation for training authentic scientists and informed citizens.

8. Learning Assessment
- **Teachers:** "We evaluate processes, not just results" (Inf. 3). "Continuous feedback is key" (Inf. 5).
- **Theory:** "Regulatory approach to learning" (Amengual, 1989, p.31). Integrated into the educational process (Alves y Acevedo, 1999, p.23).
- **Researcher:** Formative assessment democratizes learning but requires more teacher time.

9. Experimentation
- **Teachers:** "The laboratory is our best classroom" (Inf.1). "Experiments develop analytical skills" (Inf. 2).
- **Theory:** Foundation of the scientific method (Canizales et al., 2004, p.26). Goes beyond mere observation (Carvajal, 2011, p.46).
- **Researcher:** The lack of well-equipped laboratories is the main limitation for developing research competencies.

10. Hypothesis Formulation
- **Teachers:** "We teach how to propose testable predictions" (Inf. 3). "Projects include hypothesis verification" (Inf. 4).
- **Theory:** Tentative explanations (Vélez, 2001, p.18). Verifiable predictions (Espinoza, 2018, p.126).
- **Researcher:** This competency distinguishes scientific thinking from common sense.

11. Critical Data Interpretation
- **Teachers:** "We analyze data from school research" (Inf. 3). "We use basic statistics in

projects" (Inf. 5).
- **Theory:** Information evaluation with criteria (Paul y Elder, 2003, p.4). Practical application of knowledge (Educación Gratuita, 2024).
- **Researcher:** Essential skill in the era of infodemics and big data.

12. Interdisciplinarity
- **Teachers:** "We integrate biology, physics, and chemistry" (Inf. 1). "Projects address problems from multiple disciplines" (Inf. 5).
- **Theory:** Integrative vision of knowledge (Morin, 1995). "Necessary for complex problems" (Araya et al., 2006, p.407).
- **Researcher:** Breaking disciplinary barriers is the greatest current curricular challenge.

13. Research and Use of Evidence
- **Teachers:** "Students collect and analyze data" (Inf. 2). "We use technology for research" (Inf. 5).
- **Theory:** Foundation of scientific work (Ministerio de Educación, 2019a). Requires methodological rigor (Secretaría de Educación Pública, s.f).
- **Researcher:** This competency needs further development in the Venezuelan curriculum.

14. Prior Knowledge
- **Teachers:** "We start from students' prior ideas" (Inf. 3). "We connect with everyday experiences" (Inf. 3).
- **Theory:** Starting cognitive structure (Sulmont, 2022). "Anchor for new learning" (López, 2009, p.5).
- **Researcher:** Ignoring prior knowledge is the most common mistake in traditional teaching.

15. Critical thinking
- **Teachers:** "We promote evidence-based questioning" (Inf.1). "Evidence-based debates" (Inf. 5).
- **Theory:** "Strategies and mental representations people use to solve problems, make decisions, and learn new concepts" (Shaw, 2014, p.66). "Essential citizen competency" (Benzanilla et al., 2018, p.90).
- **Researcher:** Key skill to face 21st-century challenges.

16. Learning Assessment
- **Teachers:** "We combine formative and summative assessments" (Inf. 4). "We value processes, not just products" (Inf. 3).
- **Theory:** "Comprehensive curriculum approach" (Amengual, 1989, p.31). "Oriented toward improvement" (González, 1999, p.36).
- **Researcher:** Traditional assessment does not measure authentic scientific competencies.

After analyzing the aforementioned categories, the study reached a theorization phase which proposed that developing scientific and research competencies in General Secondary Education requires an educational praxis grounded in active pedagogical models that transcend traditional transmission-based approaches (Flórez, 1999).

In this regard, natural science teachers employ PBL (Problem-Based Learning) as a central strategy to develop scientific and research competencies. This approach, characterized by working with real-world problems, fosters student participation, critical thinking development, and teamwork collaboration (Instituto Tecnológico y de Estudios Superiores de Monterrey, 2010). According to Marra et al. (2014), PBL enables students to apply scientific knowledge to authentic situations, reinforcing their motivation and ability to transfer learning to everyday contexts.

Additionally, it is complemented with playful activities such as educational games, which create a dynamic learning environment and promote cognitive, emotional, and social development (Mazabuel, 2016). However, for a deeper understanding of competencies, scientific argumentation techniques are incorporated - essential for critical reasoning and collaborative knowledge construction (Ribera de Parada, 2007; Eggen & Kauchak, 2015).

Teachers implement collaborative learning to develop scientific competencies, based on "face-to-face" interactions (Johnson et al., 1994). This methodology promotes knowledge exchange, social skills, and teamwork - all essential for science as a collective practice (Bunge, 2014). According to Roselli (2016), collaboration encourages shared responsibility and joint solution-building. Collaborative projects prepare students to solve real problems (Rivera de Parada, 2004), developing critical thinking and research competencies through interdisciplinary work (Vaillant & Manso, 2019).

Experiential learning promotes scientific competencies through practical activities like laboratory dissections, where students "directly observe brain anatomy" (Inf. 2). According to Universidad del Desarrollo (2021), this approach involves applying knowledge in real contexts, strengthening critical thinking and autonomy. Kolb (1984) highlights its observation-reflection-experimentation cycle, which facilitates deep understanding and practical application of scientific concepts. Teachers report higher student motivation and development of research skills when students become active protagonists of their learning (Inf. 5).

Meaningful learning is based on connecting prior knowledge with new concepts (Tekman, 2021), enabling students to understand and apply scientific concepts in real contexts. Teachers use strategies like projects and debates to foster critical thinking (Inf. 2). This approach develops research competencies and socio-environmental awareness (Inf. 4). Complementarily, constructivism (Le Moigne in Perraudeau, 2001) promotes active learning through PBL and interdisciplinary projects (Inf. 5), where students collaboratively construct knowledge (Rosillo, 2018; Mamani, 2017).

Some teachers employ playful strategies from the sociocultural approach (Vygotsky, 2009), fostering interaction and collaborative learning in natural sciences (Inf. 4). However, a traditional transmission-based model persists, focused on the teacher and content (Flórez, 1999). Other teachers, lacking training in the area, prioritize quantitative assessments, neglecting didactic aspects. Competency-based models seek to develop investigative skills through exploration and practice (Inf. 2), while constructivism promotes direct experimentation to stimulate curiosity and autonomy (Inf. 3).

On the other hand, teachers must assume a "mediator role" (Vygotsky, 2009; Tebar, 2009), fostering autonomy and meaningful learning through practical activities (Inf. 3). While some adopt a traditional approach based on memorization and behavioral assessment (Flórez, 1999; Novak & Gowin, 1988), others promote constructivism by facilitating investigative experiences (labs, projects) that develop scientific skills (Dewey, 1960). Discovery learning requires students to actively select and analyze information (Novak & Gowin, 1988), while teachers guide through formative assessment and key questions for meaningful learning.

The use of innovative pedagogical strategies, such as artificial intelligence (AI), fosters scientific and investigative skills through active and personalized learning (Inf. 4). AI enables simulations and data analysis, promoting critical thinking and interdisciplinarity. Other techniques include: *(a) Brainstorming* (Cirigliano & Villaverde, 1981; Pimienta, 2008), which stimulates creativity through free and structured ideas. *(b) Oral presentations* (Castro, 2017), where students organize and communicate scientific knowledge. *(c) Group discussions* (Cirigliano & Villaverde, 1981), facilitating idea exchange in a collaborative environment. *(d) Question formulation* (Inf. 6), key to developing critical thinking and scientific inquiry. *(e) Problem-solving* (Inf. 4), applying theoretical knowledge in real contexts. *(f) Conversational forums* (Centro de Investigaciones y Servicios Educativos, n.d.), promoting reflective dialogue. *(g) Debates* (Cirigliano & Villaverde, 1981; Pimienta, 2008), encouraging argumentation and participation (Inf. 4, 5, and 6).

Regarding the axial category of learning assessment in natural sciences, this adopts a formative and *process-oriented* character, allowing teachers to identify deviations and adjust pedagogical strategies (Flórez, 1999; Amengual, 1989).

Formative assessment, highlighted in teacher testimonies (Inf. 5 and 6), provides real-time feedback, facilitating continuous improvement. Stefflebeam (1987) emphasizes its role as a guide for decision-making, while *summative assessment* (Camilloni, 1998) certifies learning achievements and scientific competencies, integrating hypothesis formulation, experimentation, and analysis (Inf. 5).

Process-oriented assessment (Alves y Acevedo, 1999) evaluates performance, attitude, and achievement (Estévez, 2000), transcending final results. Techniques such as *observation* (anecdotal records, rating scales) allow assessment of practical and collaborative skills (Inf. 2, 4 and 6), though they require careful implementation to avoid subjective biases. Instruments like descriptive journals (Inf. 5) and checklists optimize objectivity.

On the other hand, from an integrative framework and by way of synthesis, it is proposed that scientific and *research competencies* constitute a fundamental pillar in contemporary educational formation, integrating cognitive, procedural, and attitudinal dimensions. From a constructivist perspective (Vygotsky, 1978; Piaget, 1968), these competencies transcend mere knowledge acquisition, promoting essential skills for critical analysis and complex problem-solving. *Cognitive competencies* involve the ability to analyze, understand, interpret, and explain scientific concepts or phenomena. These include:

- *Scientific argumentation:* The ability to structure evidence-based reasoning, fundamental for communicating findings and refuting ideas. "When an argument is proposed, a reason is given to think its conclusion is true" (Iacona, 2018, p.65). "The ability to formulate questions, experiment, and effectively communicate findings" (Inf.5) is a core competency in the scientific process, as it promotes structured communication supporting conclusions with solid evidence.
- *Understanding scientific concepts:* An essential skill for developing research competencies, involving not just memorization but the ability to understand and interrelate concepts. According to Pérez (2008, p.76), it is a "theoretical construction aimed at predicting experimental outcomes and explaining established facts."
- *Explaining phenomena scientifically:* "The fact exists or is available to the researcher before constructing the theory meant to explain it" (Díaz et al., 2005, p.101), implying observable reality must be interpreted through integrating diverse approaches and theories.
- *Hypothesis formulation:* The ability to make grounded predictions based on scientific knowledge and pattern observation - learning to plan "problems emerging from analyzing theoretical-empirical knowledge relationships" (Díaz et al., 2005, p.100).
- *Critical thinking:* The capacity to respond to environmental problems (Guzmán et al., 2019).
- *Critical interpretation of data/evidence: Involves evaluating obtained information to draw valid, well-founded conclusions.*

On the other hand, there are procedural competencies that integrate essential practical skills for scientific research such as inquiry. These competencies foster the application of the scientific method in real-world contexts, developing observation, critical analysis, and problem-solving skills (Inf. 2). Active experimentation - such as studying reflex arcs in amphibians (Inf. 6) - reinforces meaningful learning by linking theory and practice (Inf. 2), preparing students for contemporary scientific challenges.

These competencies consist of: *(a) Building and evaluating designs/prototypes:* Involves applying scientific knowledge to create and improve experimental models or devices. Through these activities, students are given the opportunity to "design creative and effective solutions" (Inf. 4) that address contemporary problems. *(b) Inquiry:* A fundamental pillar in science education, as it drives students to explore, question, and discover the world around them.

Regarding attitudinal competencies, this group includes competencies that foster essential attitudes for scientific work. Among these stand out: *(a) Developing curiosity and critical thinking:*

"Fostering curiosity and critical thinking is key to helping students understand and internalize scientific and research competencies" (Inf. 2). *(b) Researching, evaluating, and using scientific information:* Involves the attitude of constant knowledge-seeking and the ability to discern between valid and invalid information sources. "It requires identifying and solving problems in real contexts to address actual issues" (Inf. 3).

It should be noted that developing scientific competencies transcends mere knowledge acquisition, integrating cognitive, procedural, and attitudinal dimensions. From a constructivist approach, it promotes *critical thinking* (analysis, evaluation, and synthesis of information), *scientific argumentation* (structuring evidence-based ideas), and *inquiry* (hypothesis formulation and experimental design). These competencies enhance metacognitive skills and complex problem-solving through an interdisciplinary framework. Additionally, attitudes like curiosity, ethical commitment, and creativity are essential for applying scientific knowledge in real contexts, strengthening the theory-practice connection. Effective communication (oral, written, and digital) completes this profile, ensuring knowledge transferability.

Conclusions

At the conclusion of this article, it is determined that the analyzed theoretical frameworks emphasize the need to transition from a traditional educational model to an interdisciplinary one focused on developing scientific and research competencies. Constructivist theories (Piaget, Vygotsky, Ausubel) and active models (investigation, discovery) provide tools for designing pedagogical practices that foster curiosity, critical thinking, and knowledge application in real contexts. Integrating these perspectives with innovative teaching strategies can transform classrooms into spaces where students not only learn science but think and act like scientists.

Similarly, it is concluded that educational praxis in scientific and research competencies is grounded in active pedagogical models, such as *problem-based and project-based learning, which* promote knowledge application in real-world contexts. These methodologies, combined with strategies like *debates* and *group discussions*, encourage critical thinking and collaborative knowledge construction. *Formative assessment*, with continuous feedback and clear criteria, ensures meaningful and adaptive learning. Integrating these student-centered approaches enriches the educational process, preparing students for academic and professional challenges with analytical, creative, and collaborative tools.

Finally, it is concluded that scientific and research competencies are articulated through three key dimensions: *(a) Cognitive* (critical thinking, evidence-based argumentation, and interdisciplinary understanding of phenomena, grounded in theories like those of Piaget and Vygotsky). *(b) Procedural* (inquiry, data interpretation, and prototype construction, following Bruner and Dewey's "learning by doing" approach). *(c) Attitudinal* (curiosity as a learning driver and scientific ethics). These competencies, integrated into General Secondary Education, shape citizens capable of solving complex problems, innovating, and assuming responsibilities in an interconnected world, combining scientific rigor with creativity and social awareness.

References

Alves, E. and Acevedo, R. (1999). *La evaluación cualitativa. Reflexiones para la transformación de* la realidad educativa. Ediciones Cerined.

Amengual, B. R. (1989). *Evaluación formativa.* Editorial Cincel.

Arias, G, J. (2017). Problemas y retos de la educación rural colombiana. *Educación y Ciudad,* 33, 53-62. https://revistas.idep.edu.co/index.php/educacion-y-ciudad/article/view/1647

Barón, P. L. L. (2019). *Formación metodológica para el desarrollo de competencias investigativas en docentes de la asignatura de investigación de educación básica y media.* https://repositorio.umecit.edu.pa/bitstream/handle/001/2826/Tesis%20final %20Lorena%20Bar%c3%b3n-1.pdf?sequence=1&isAllowed=y

Benzanilla, A. M. J., Poblete, R. M., Fernández, N. D., Arranz, T. A. and Campo, C. L. (2018). El Pensamiento Crítico desde la Perspectiva de los Docentes Universitarios. E*studios Pedagógicos,* 44(1), pp. 89-113. https://www.scielo.cl/pdf/estped/ v44n1/0718-0705-estped-44-01-00089.pdf

Bruner, J. S. (1968). *El proceso de la educación.* Unión Tipográfica Editorial Hispano.

Bunge, M. (2014). *La ciencia, su método y su filosofía.* Editorial Sudamericana.

Castro, L. I. (2017). *La Exposición como Estrategia de Aprendizaje y Evaluación en el Aula.* Editorial Razón y Palabra.

Centro de Investigaciones y Servicios Educativos. (s.f). *El conversatorio como una técnica de aprendizaje.* https://www.cise.espol.edu.ec/sites/cise.espol.edu.ec/files/Guía%20didáctica.-%20Raíces%20y%20moda.pdf

Charmaz, K. (2013). *La teoría fundamentada en el siglo XXI: Aplicaciones para promover estudios sobre la justicia social.* Gedisa.

Chomsky, N. (1970). *Aspectos de la teoría de la sintaxis.* Aguilar.

Cirigliano, G. F. J. y Villaverde, A. (1981). *Dinámicas de grupo y educación.* 14ª edición. Hvmanitas.

Coll, C., Martín, E., Mauri, T., Miras, M., Onrubia, J. Solé, I and Zabala, A. (1999). *El constructivismo en el aula.* Grao.

Dewey, J. (1960). *Experiencia y educación.* Editorial Losada.

Díaz, B. F. and Hernández, G. (2004). *Estrategias docentes para un aprendizaje significativo: una interpretación constructivista*. McGraw-Hill Interamericana.

Díaz, N. V. P., Calzadilla, N. A and López, S. H. (2005). Una aproximación al concepto de hecho científico. *Cinta de Moebio. Revista de Epistemología de Ciencias Sociales*, (22), 100-111. https://revistadesociologia.uchile.cl/index.php/CDM/article/view/26088

Eggen, P. and Kauchak, D. (2015). *Estrategias docentes. Enseñanza de contenidos curriculares y desarrollo de habilidades de pensamiento*. Fondo de Cultura Económica.

Figueroa, S, M. F. (2017). *Estrategia de aprendizaje para desarrollar habilidades investigativas en los estudiantes de la Escuela de Cultura Física de la Universidad Técnica de Babahoyo*. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiGlp3J-8uAAxWS_rsIHStwDMoQFnoECBMQAQ&url=https%3A%2F%2Fcyber-tesis.unmsm.edu.pe%2Fhandle%2F20.500.12672%2F6965&usg=AOvVaw2LWDhNc4Bi2TlNQig_bfpb&opi=89978449

Flórez, O. R. (1999). *Evaluación pedagógica y cognición*. McGrawHill.

Freire, P., (2012). *Pedagogía del Oprimido*. Siglo XXI.

Frola, P. and Velásquez, J. (2011). *Estrategias didácticas por competencias diseños eficientes de intervenciónpedagógica*. Centro de Investigación Educativa y Capacitación Institucional.

Gadamer, H, G. (1984). *Verdad y método: fundamentos de una hermenéutica filosófica*. Salamanca: Sígueme.

Galeano, M, M. E. (2020). *Diseño de proyectos en la investigación cualitativa*. Fondo Editorial Universidad EAFIT.

Gamboa, S, A. A., Hernández, S, C. A. and Prada, N, R. (2020). Competencias científicas, investigativas y comunicativas: experiencias desde una línea de investigación en enseñanza de las Ciencias. *Plumilla Educativa*, 14(1), 13-26. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiLpLfv7q-JAxU2SzABHWoPPQcQFnoECBkQAQ&url=https%3A%2F%2Frevistasum.um anizales.edu.co%2Fojs%2Findex.php%2Fplumillaeducativa%2Farticle%2Fview%2F3827&usg=AOvVaw1k3KhBYkyqPWD9j44ZkYsh&opi=89978449

Gardner, H. (2000). *La educación de la mente y el conocimiento de las disciplinas*. Paidós.

Gil, P. D. (1993). Contribución de la historia y de la filosofía de las ciencias al desarrollo de un modelo de enseñanza/aprendizaje como investigación. *Enseñanza de las ciencias. Revista de investigación y experiencias didácticas*, 11(2), 197-212. https://www.

google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjiq5mq76-JAxULSTABHbSbNrAQFnoECBYQAQ&url=http%3A%2F%2Fenvia3.xoc.uam.mx%2Fsite%2Fuploads%2Flecturas_TID%2Funidad1%2FGil%2520Perez.pdf&usg=AOvVaw2YoXRTZFYOl6vHwprWMcxG&opi=89978449

González, M. (1999). *La evaluación del aprendizaje en la enseñanza universitaria*. CEPES, Universidad de La Habana.

Guzmán, D. A. P., Oliveros, C. D. and Mendoza, G. E. M. (2019). Las competencias científicas a partir de la gestión del conocimiento en instituciones de educación superior. *Signos-Investigación en Sistemas de Gestión*, 11(2), 23-40. https://www. redalyc.org/journal/5604/560460636001/html/#:~:text=Las%20competencias%20científicas%20favorecen%20el,a%20los%20profesionales%20recién%20graduados

Herrera, P., P. R. (2016). *El desafío de los profesores para aplicar el enfoque indagatorio en sus clases de ciencias: Análisis del proceso de apropiación del enfoque indagatorio en la enseñanza de las ciencias por parte de profesores de educación parvularia y básica a través de un proceso de asistencia técnica educativa*. https://dialnet.unirioja.es/servlet/tesis?codigo=80942

Hymes, D. (1986). *Acerca de la competencia comunicativa: Forma y Función*. Universidad Nacional de Colombia.

Iacona, A. (2018). *La argumentación*. Universidad Autónoma de Maduro. https://casadelibrosabiertos.uam.mx/contenido/contenido/Libroelectronico /Argumentacion.pdf

Instituto Tecnológico y de Estudios Superiores de Monterrey. (2010). *Las estrategias y técnicas didácticas en el rediseño. El Aprendizaje Basado en Problemas como técnica didáctica*. https://sitios.itesm.mx/va/dide2/tecnicas_didacticas/abp/abp.pdf

Johnson. D. W., Johnson, R. T. and Holubec, E. J. (1994). *El aprendizaje cooperativo en el aula*. Editorial Paidós. https://www.ucm.es/data/cont/docs/1626-2019-03-15-JOHNSON%20El%20aprendizaje%20cooperativo%20en%20el%20aula.pdf

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice-Hall.

Latorre, M. (2017). *Aprendizaje Significativo y Funcional*. Universidad Champagnat.

Ley 30 de 1992. (Diciembre 28). *Diario Oficial No. 40.700, de 29 de diciembre de 1992*. https://www.oas.org/juridico/spanish/mesicic2_col_ley_30_sp.pdf

López, R. J. A. (2009). *La importancia de los conocimientos previos para el aprendizaje de nuevos contenidos*. https://archivos.csif.es/archivos/andalucia/ensenanza/revistas/ csicsif/revista/pdf/Numero_16/JOSE%20ANTONIO_LOPEZ_1.pdf

Lupión C, T. and Martín, G, C. (2016). Desarrollo profesional docente de profesorado. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, 13(3), 686-705. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiMqdG1jbSJAxVGRjABHaCLEA0QFnoECBAQAQ&url=https%3A%2F%2Frevistas.uca.es%2Findex.php%2Feureka%2Farticle%2Fview%2F2999&usg=AOvVaw1rQeJGnz5pfZkRhzNlgd0d&opi=89978449

Mamani, C. W. (2017). *Constructivismo y socioconstructivismo*. Asociación Educativo. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi7pq_rsJiJAxUCSzABHbdYAn8QFnoECBUQAQ&url=https%3A%2F%2Fugelpuno.edu.pe%2Fweb%2Fwp-content%2Fuploads%2F2017%2F05%2FConstructivismo-y-socioconstructivismo_-feb-2017OK.pdf&usg=AOvVaw1hYHM9x_M0aJhoy2fcaUPY& opi=89978449

Marra, R., Jonassen, D. H., Palmer, B. & Luft, S. (2014). Why problem- based learning works: Theoretical foundations. *Journal on Excellence in College Teaching*, 25(3-4), 221-238. https://www.albany.edu/cee/assets/Why_Problem-based_learning_works. pdf

Martínez, M, M. (2012). *Comportamiento humano. Nuevos métodos de investigación*. 2a edición ed. Trillas.

Mazabuel, C. F. (2016). *El Aprendizaje Basado en Problemas (ABP) y los juegos tradicionales, como estrategias para el desarrollo de habilidades metacognitivas en el aprendizaje de las matemáticas, en los estudiantes del grado quinto de básica primaria de la Institución Educativa Políndara del Municipio de Totoró*. Trabajo de grado de la Maestría en Educación desde la Diversidad. Universidad de Manizales, Popayán – Colombia. https://ridum.umanizales.edu.co/bitstream/handle/20.500.12746/2737/PROYECTO%20DE%20GRADO%20CARLOS%20MAZABUEL2016%20MAESTRIA.pdf?sequence=2&isAllowed=y.

Ministerio de Educación. (2019a). *Habilidades y etapas de la investigación científica*. https://www.curriculumnacional.cl/portal/Ejes/Ciencias-Naturales/Habilidades-y-etapas-de-la-investigacion-cienti fica/

Ministerio del Poder Popular para la Educación. (2017). Áreas de Formación en Educación Media General. Ministerio del Poder Popular para la Educación.

Moreira, M. (2017). Aprendizaje significativo como un referente para la organización de la enseñanza. *Archivos de Ciencias de la Educación*, 11 (12), e29. https://www.memoria.fahce.unlp.edu.ar/art_revistas/pr.8290/pr.8290.pdf

Novak, J. D. and Gowin, D. B. (1988). *Aprendiendo a aprender*. Martínez Roca.

Otálora, S. S. (2009). *La enseñanza para la comprensión como estrategia pedagógica en la formación de docentes*. *Revista temas*, 3. 121-130. https://dialnet. unirioja.es/servlet/articulo?codigo=5894332

Pérez, M. L. A. (2008). Estructura y uso de los conceptos científicos. *Krei*, (10), 75-87. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj0pYnn5a-JAxVzRjABHdYiB-4QFnoECBcQAQ&url=https%3A%2F%2Fdialnet.unirioja.es%2Fdescarga%2Farticulo%2F3202584.pdf&usg=AOvVaw0xLkVV6pOb9XWSxdoF3Zt&opi=89978449

Perraudeau, M. (2001). *Piaget Hoy. Respuestas a Una Controversia*. Fondo de Cultura Económica.

Perrenoud, Ph. (1999). *Construir las Competencias desde la Escuela.* Artmed Editora.

Piaget, J. (1968a). *Psicología y pedagogía.* Ariel.

Piaget, J. (1968b). *Los estadios del desarrollo intelectual del niño y del adolescente*. Editorial Revolucionaria.

Pimienta, P. J. H. (2008). *Constructivismo. Estrategias para aprender a aprender*. 3ª edición. Pearson Educación.

Porlán, R. (2002). *Constructivismo y Escuela. Hacia un modelo de enseñanza-aprendizaje basado en la investigación*. 6ª. Ed. Díada Editoral S.L.

Pozo, J. I. and Gómez, C, M. Á. (2010). Por qué los alumnos no comprenden la ciencia que aprenden. *Alambique, Didáctica de las Ciencias Experimentales*, 66, 74-79.

Ribera de Parada, A. (2007). Aprendizaje Basado en Problemas (ABP). Estrategia para dinamizar la cátedra universitaria. *Población y desarrollo*, (4), 29–35. https://doi.org/10.5377/creaciencia.v0i4.9161

Rivera, L. J. M. (2004). El aprendizaje significativo y la evaluación de los aprendizajes. *Revista de investigación educativa año*, 8(14), 47-52. http://online.aliat.edu. mx/adistancia/dinamica/lecturas/El_aprendizaje_significativo.pdf

Rojas de Escalona, B. (2010). *Investigación cualitativa: fundamentos y praxis.* 2a ed. FEDEUPEL.

Roselli, N. D. (2016). El aprendizaje colaborativo: Bases teóricas y estrategias aplicables en la enseñanza universitaria. *Propósitos y Representaciones*, 4(1), 219-280. doi: http://dx.doi.org/10.20511/pyr2016.v4n1.90

Rosillo, J. J. (2018). Constructivismo y socioconstructivismo. https://danielalmeyda.wordpress.com/wp-content/uploads/2018/03/tema-1-constructivis mo -y-socioconstructivismo.pdf

Samper, B. A. and Ramírez, L. A. (2014). *Diseño de una propuesta pedagógica de educación para* *la seguridad vial estructurada bajo el modelo de aprendizaje experiencia*. Corporación Universitaria Minuto de Dios. https://repository.uniminuto.edu/server/ api/core/bitstreams/df21c205-3903-40dc-823ef7ebb556fa09/content

Sánchez, S. I. R. and Herrera San Martín, E. d. C. (2019). Aprendizaje significativo y desarrollo de competencias científicas en física a través de la Uve Gowin. *Revista electrónica de investigación en educación en ciencias*, 14(2), 17-28. https://www.scielo.org.ar/scielo.php?script=sci_abstract&pid=S1850-66662019000200002

Secretaría de Educación Pública. (s.f). *Área de conocimiento Ciencias Naturales. Documento de trabajo y de consulta para propiciar el diálogo y el intercambio de ideas y puntos de vista con las comunidades educativas de la Educación Media Superior en México.* https://educacionmediasuperior.sep.gob.mx/work/models/sems/Resource/13516/1/images/Ciencias%20naturales%20s.pdf

Shaw, R. D. (2014). How Critical Is Critical Thinking. *Music Educators Journal*, 101(2), 65-70. http://journals.sagepub.com/doi/abs/10.1177/0027432114544 376

Stufflebeam, D. and Shinkfield, A. J. (1987). *Evaluación sistemáfica: guía teórica y práctica*. Paidós-MEC.

Sulmont, L. (2022). ¿Qué tal si revisamos en qué consisten los conocimientos previos? *Educared* https://educared.fundaciontelefonica.com.pe/que-tal-si/que-tal-si-revisamos-en-que-consisten-los-conocimientos-previos/

Tébar, B. L. (2009). *El profesor mediador del aprendizaje*. Magisterio.

Tekman. (2021). ¿Qué estrategias utilizar para alcanzar un aprendizaje significativo en el aula? *Blog 13/04/2021*. https://www.tekmaneducation.com/aprendizaje-significativo-aula/

Thrive Teaching. (2024). *La curiosidad potencia su capacidad de pensamiento crítico*. https://thriveteaching.org/es/curiosity/

Tobón, S. (2006a). *Las competencias en la educación superior.* ECOE.

Tobón, S. (2006b). *Aspectos básico de la formación basada en competencias*. Proyecto Mesesup.

Universidad del Desarrollo. (2021). *7 consejos para implementar el Aprendizaje Experiencial*. https://practicaspedagogicaspsicologia.udd.cl/files/2020/11/plantilla5_a_experiencial.pdf

Vaillant, D. y Manso, J. (2019). *Orientaciones para la Formación Docente y el Trabajo en el aula: Aprendizaje Colaborativo*. SUMMA Laboratorio de Investigación e Innovación en Educación para América Latina y el Caribe. https://panorama.oei. org.ar/_dev2/wp-content/uploads/2019/05/APRENDIZAJE-COLABORATIVO.pdf

Veloza, R, R. A. and Hernández, S, C. A. (2018). *Valoración de las estrategias adoptadas por docentes en la enseñanza de la ciencia desde la perspectiva de los estudiantes de educación básica.* https://publicaciones.autonoma.edu.co/index. php/anfora/article/view/512

Vigotsky, L. S. (1985). *Pensamiento y Lenguaje.* La Pléyade.

Vigotsky, L. S. (2009). *El Desarrollo de los Procesos Psicológicos Superiores.* 3ª ed. Crítica.