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Physics as experience: an approach to physics content in the natural sciences subject in general basic education

La Física como experiencia: Un enfoque de los contenidos de Física en la materia de Ciencias Naturales en Educación General Básica

José Ricardo Aulestia Ortiz[1]
William Arnulfo Meneses Rodríguez[2]
Jorge Washington Encalada Noboa[3]
Kelly Daysi Hernández Mite[4]

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Correspondence author
jraulestia@uce.edu.ec

Master's Degree in Teaching in Higher Education Institutions
Central University of Ecuador
jraulestia@uce.edu.ec
https://orcid.org/0000-0001-5825-2487

Master's Degree in Educational Management and Leadership
Central University of Ecuador
wameneses@uce.edu.ec
https://orcid.org/0009-0006-2411-600X

Master's Degree in Physics Teaching
University of Guayaquil
jorge.encaladan@ug.edu.ec
https://orcid.org/0000-0002-2884-5596

Master's Degree in Recreation and Leisure Time
University of Guayaquil
kelly.hernandezm@ug.edu.ec
https://orcid.org/0000-0002-7061-9402

Abstract: This article presents a critical review of the experiential approach in the teaching of physics within the subject of Natural Sciences in General Basic Education. From the analysis of twenty-five studies published between 2020 and 2024, the main pedagogical strategies based on experimentation, inquiry, use of low-cost materials, outings to the environment and interactive digital tools are identified. The results show that these strategies promote meaningful learning, improve attitudes towards physics and foster the development of scientific thinking from an early age. In addition, it is evident that this approach is viable in contexts with limited resources and that it can be implemented gradually by creative and committed teachers. The study concludes that teaching physics as a concrete experience contributes to the formation of a critical and active scientific citizenship, and is aligned with the curricular objectives of basic education in Ecuador and Latin America. The conclusions highlight the importance of strengthening teacher training and consolidating school practices that recognize science as an experiential, contextualized and meaningful experience.

Key words: physics teaching, active learning, natural sciences, basic education.

Resumen: Este artículo presenta una revisión crítica sobre el enfoque experiencial en la enseñanza de la física dentro de la asignatura de Ciencias Naturales en la Educación General Básica. A partir del análisis de veinticinco estudios publicados entre 2020 y 2024, se identifican las principales estrategias pedagógicas basadas en la experimentación, la indagación, el uso de materiales de bajo costo, las salidas al entorno y las herramientas digitales interactivas. Los resultados muestran que dichas estrategias promueven un aprendizaje significativo, mejoran la actitud hacia la física y fomentan el desarrollo del pensamiento científico desde edades tempranas. Además, se evidencia que este enfoque es viable en contextos con limitaciones de recursos y que puede implementarse de manera gradual por docentes creativos y comprometidos. El estudio concluye que enseñar física como experiencia concreta contribuye a la formación de una ciudadanía científica crítica y activa, y se alinea con los objetivos curriculares de la educación básica en Ecuador y América Latina. Las conclusiones destacan la importancia de fortalecer la formación docente y de consolidar prácticas escolares que reconozcan la ciencia como una experiencia vivencial, contextualizada y significativa.

Palabras clave: enseñanza de la física, aprendizaje activo, ciencias naturales, educación básica.

Introduction

In the context of General Basic Education (EGB), the teaching of Natural Sciences represents a privileged opportunity to stimulate critical thinking, wonder about the natural environment and the development of fundamental scientific skills. However, one of the greatest challenges in this field is to ensure that physics content, which is often perceived as abstract, is understood in a meaningful way by students. Despite the fact that in the early school years children interact with physical phenomena constantly, such as falling objects, movement, heat or light, these experiences do not always translate into

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solid learning if they are not guided by an appropriate methodological approach (Rojas-Murillo et al., 2021).

In the last decades, several researches have agreed on the need to rethink the traditional approach to the teaching of physics at basic levels. Numerous studies have shown that approaches focused on the transmission of decontextualized content and the memorization of formulas are ineffective in promoting lasting learning, especially at the early school levels (Tavares et al., 2022; González & Ocampo, 2023). In contrast, there is a need to articulate an experiential approach, where physical knowledge is built from observation, manipulation of materials, dialogue with the teacher and peers, and direct linkage with the everyday environment.

This experiential approach finds support in the theoretical bases of constructivism, especially in the ideas of Piaget and Vygotsky, who emphasized that knowledge is actively constructed when the individual interacts with his environment, explores and reflects on his discoveries. Similarly, John Dewey's pedagogy insists that authentic learning comes from direct experience, solving real problems and active learning, ideas that today are revitalized in the field of science education (García-Sancho et al., 2021). Applied to physics, this implies promoting activities where students can "see, touch and experiment" with physical phenomena, which facilitates their understanding and their connection with the world.

Several empirical studies have confirmed that the use of active and experimental strategies in physics teaching contributes to increased interest, concept retention and the development of scientific thinking from an early age (Medina-Hernández & Zúñiga, 2020; López & Cabrera, 2022). For example, the incorporation of simple experiments, carried out with accessible materials, allows explaining phenomena such as equilibrium, static electricity or sound in a concrete, motivating and affordable way for GBS students. These practices not only develop cognitive skills, but also scientific attitudes such as curiosity, respect for evidence and willingness to question.

In the particular case of Latin America, and specifically in Ecuador, significant efforts have been made to improve the quality of science teaching in basic education. However, rigid approaches still persist, focused on the memorization of concepts and the mechanical resolution of exercises (INEVAL, 2021). This is aggravated by the scarce specialized training in physics that many Natural Sciences teachers at the GBS level possess, which limits the possibility of offering meaningful experiences to students. Faced with this situation, recent research suggests that one of the keys to transform this reality lies in offering pedagogical proposals that articulate physics with direct experience of the environment and with teacher creativity (Cevallos et al., 2022).

Within this framework, teaching physics as an experience not only implies a methodological transformation, but also a revaluation of the teacher's role as a mediator between the physical phenomenon and the students' understanding. The teacher ceases to be a transmitter of information to become a facilitator of experiences, who guides observation, asks questions, encourages inquiry and promotes discussion. This vision is aligned with the competency approach proposed in current curricula, where students are expected to develop skills for lifelong learning, solve problems and act responsibly towards the environment (Ministry of Education of Ecuador, 2016).

The experiential approach in the teaching of physics is especially relevant in the context of General Basic Education because students are at a stage of cognitive development where concrete thinking predominates over abstract thinking. According to Piaget, children between the ages of 7 and 12 are in the stage of concrete operations, which means that they need to manipulate objects and experiment directly with phenomena in order to understand them effectively (Piaget, 1972). Consequently, trying to introduce physical concepts only through verbal explanations or readings without previous experiences can generate disinterest, incomprehension or an erroneous conceptualization of the phenomena.

A recent review of pedagogical practices in elementary and middle school education in Latin American contexts found that the most effective strategies for teaching physics to children were those that combined play, experimentation and collaborative work (Sánchez-Villavicencio et al., 2021). These strategies not only favor the development of cognitive skills, but also socioemotional skills, such as cooperation, perseverance and assertive communication, aligned with the comprehensive training approach promoted by current curricular frameworks.

Likewise, the use of contextualized physical experiences makes it possible to generate meaningful learning. According to Ausubel (2002), learning is meaningful when new knowledge is related to the learner's previous structures. In this sense, if the teaching manages to link a physical concept with real situations experienced by the

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students -such as the use of a pulley to lift a bucket, the sound of a vibrating rope or the heat of the sun on a metal-, the probabilities that the knowledge will be incorporated in a lasting and functional way are increased. Thus, experience becomes the gateway to formal knowledge.

In addition, the student's everyday environment can be a natural laboratory for discovering physics. An experiential approach recognizes that phenomena such as gravity, pressure, light reflection or energy transformation are present in everyday life and can be explored with a scientific eye. This vision is in line with international trends promoting Science Education for All, where it is considered that scientific literacy should start from the early school years as a way to foster a critical, informed citizenry capable of actively participating in the knowledge society (Bybee, 2020).

In this context, the role of the teacher as a designer of experiences becomes vitally important. Several investigations highlight that teachers who adopt a reflective, investigative and creative attitude can transform science classrooms into spaces of discovery and wonder (Pineda & Delgado, 2020). However, for this to happen, it is essential that teachers receive continuous training and relevant didactic resources. In countries such as Ecuador, where many natural science teachers come from general and not specific training in physics, it is necessary to implement teacher updating programs with emphasis on experimental strategies, guided inquiry and design of contextualized practical activities (Ortiz et al., 2023).

On the other hand, digital technologies now offer complementary tools that enhance the experiential approach. Platforms such as PhET Interactive Simulations, developed by the University of Colorado, allow students to interact with virtual models of physical phenomena, which is especially useful when material resources are scarce or when seeking to complement the physical experience with simulation (Wieman et al., 2020). These simulators are accessible, engaging, and allow students to observe how results vary as a variable is modified, thereby strengthening their conceptual understanding and their ability to formulate hypotheses and conclusions.

The academic literature has also documented how the implementation of school projects, science fairs, and open-ended inquiry activities promote deeper learning in physics. For example, when students build their own measuring instruments (such as a balance, compass, or thermometer), they not only better understand the physical principles involved, but also develop technical skills, logical thinking, and autonomy (Carrillo & Guzmán, 2021). These activities allow students to feel as protagonists of their learning process and revalue scientific knowledge as a useful tool to understand and transform their reality.

In the context of GBS, curricular proposals should consider this evidence and promote the teaching of physics not as a series of decontextualized definitions and formulas, but as a way of exploring the world, asking questions, seeking answers and marveling at nature. The Ecuadorian curriculum, for example, establishes as one of the objectives of the subject of Natural Sciences to "develop scientific thinking through observation, experimentation and critical analysis of natural phenomena" (Ministry of Education of Ecuador, 2016, p. 8), which opens an important door to propose strategies focused on experience.

However, the reality of the classroom many times shows a gap between the ideal curriculum and the actual teaching practice. Factors such as the number of students per classroom, the lack of school laboratories, the limited time for planning or the pressure to cover assessable content tend to discourage the implementation of experiential proposals. In response to this, several studies have advocated the use of low-cost and easy-to-implement experiments, which can be carried out with recyclable or everyday materials, such as bottles, spoons, rulers, balloons, batteries, paper clips or mirrors (Martínez et al., 2020). These practices allow democratizing access to scientific knowledge and show that teaching physics with meaningful experiences does not require large investments, but creativity and pedagogical commitment.

It should be noted that the experiential approach does not intend to replace the theoretical knowledge that is an essential part of learning physics, but rather to provide it with meaning and functionality. The frequent error in some traditional approaches has been to present physical concepts as immovable dogmas, detached from everyday life and the students' capacity for wonder. In contrast, when teaching is based on experience and active inquiry, knowledge becomes dynamic, open to exploration and constant reinterpretation.

This type of teaching also requires a transformation in assessment. Conventional evaluations, centered on closed questions or the resolution of standard exercises, do not adequately capture the learning processes involved in physical experiences. Instead, tools such as the portfolio of experiments, observation rubrics, field

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journals or self-assessments may be more relevant to assess not only learning products, but also the processes of observation, inference, collaboration and reflection (Salas & Montenegro, 2021). These strategies also help to diversify assessment and to value creativity, effort, initiative and active participation of students.

Quality science education not only seeks to train future scientists or technicians, but mainly informed, critical citizens committed to their environment. Teaching physics from experience allows students to cultivate the ability to observe carefully, to ask questions, to understand how the natural world works and to intervene in it responsibly. In times of intensifying environmental and technological challenges, developing an early and deep understanding of physical principles can contribute to forming more aware, informed and creative generations.

Furthermore, in the digital age in which today's students live, physical experiences must be complemented with interactive resources that enhance visualization, virtual experimentation and gamification of learning. The use of simulators, educational apps and adaptive learning platforms can enrich face-to-face experiences, provide immediate feedback and encourage an attitude of autonomous exploration. However, it is essential that these tools do not replace direct experience, but rather amplify it, respecting the active and bodily nature of learning in childhood (Gómez-Vargas & Herrera, 2022).

Finally, it is pertinent to point out that the "physics as experience" approach also represents an opportunity to redefine the image of physics as a difficult or inaccessible science. If students experience from an early age that physics is present in their daily lives, that they can understand it in their own words, explore it with their hands and share it with their peers, they are more likely to develop a positive attitude towards it and be interested in continuing their learning at higher levels.

Therefore, the purpose of this study is to support, from an academic and pedagogical review, the relevance of an experiential approach to the teaching of physics in the subject of Natural Sciences in General Basic Education, highlighting its benefits, challenges and projections to improve the quality of scientific learning from the early school years.

Methodology

The present study adopts a qualitative methodology, oriented under an exploratory and documentary approach, which aims to critically examine the experiential approach to the teaching of physics in General Basic Education (EGB), especially within the subject of Natural Sciences. This methodological choice responds to the need to systematize, analyze and compare different didactic proposals, pedagogical experiences and empirical studies developed in recent years, both in the Latin American context and in international educational scenarios, in order to support the relevance of integrating concrete experiences in the learning of physical contents from an early age.

The methodological strategy was structured on the basis of an exhaustive bibliographic review of academic sources indexed in scientific databases such as Scopus, ERIC, RedALyC, Scielo and Dialnet, prioritizing articles published between 2020 and 2024 to ensure the timeliness of the analysis. Inclusion criteria were established that included: (a) research focused on the teaching of physics in basic education, (b) studies that promote active or experiential approaches, (c) methodological proposals based on learning through discovery, inquiry, or experimentation, and (d) studies contextualized in countries with educational systems comparable to Ecuador. As exclusion criteria, works with purely theoretical approaches without concrete didactic application or publications prior to 2020 were excluded, except those that constitute fundamental theoretical frameworks (such as Piaget or Ausubel).

The analysis of the information was carried out in three stages: the first consisted of an exploratory reading of the summaries of more than fifty documents to identify those most relevant to the object of study. In the second stage, an analytical and critical reading of twenty-five selected documents was carried out, extracting key ideas, pedagogical strategies, empirical results and limitations reported in each case. Finally, we proceeded to an interpretative synthesis, articulating the findings with the conceptual frameworks of constructivism, meaningful learning, and experience-based learning, in order to elaborate a solid body of arguments to support the central pedagogical proposal of the article.

This methodological design also allowed us to identify the current trends in physics teaching in GBS, the most common barriers to the implementation of experiential practices (such as lack of teacher training or resources), and the possible documented solutions, such as the use of digital simulators or low-cost materials. Additionally, the feasibility of applying these strategies in the Ecuadorian context was assessed, based on their alignment with the current curriculum of the Ministry of Education and the pedagogical resources available at the basic level.

It is important to point out that, being a documentary review, this study did not involve field work or primary data collection, but was based on the critical interpretation of secondary evidence. Nevertheless, its value lies in the rigorous systematization of existing knowledge, which can guide both future research and pedagogical decisions in the classroom. The adopted methodology allows, therefore, to establish a solid referential framework that contributes to the design and implementation of innovative, contextualized and grounded practices for the teaching of physics as a meaningful experience in General Basic Education.

Results

From the review of twenty-five recent academic studies, multiple evidences were identified that support the effectiveness of the experiential approach for teaching physics at the General Basic Education level. One of the most recurrent findings was that strategies based on direct manipulation of objects, exploration of the environment and problem solving from real situations allow for a deeper understanding and meaningful understanding of physical concepts. These strategies, in addition to facilitating conceptual acquisition, foster positive attitudes towards science, such as curiosity, perseverance and interest in understanding the natural world (Tavares et al., 2022; Medina-Hernández & Zúñiga, 2020).

The reviewed studies agree that low-cost experiments, designed with homemade or recycled materials, allow representing phenomena such as equilibrium, atmospheric pressure, density or light reflection in an accessible way for students between 8 and 13 years old. In particular, the work of Pavón et al. (2021), who documented experiences in Ecuadorian educational institutions where these practices not only improved academic performance in physics, but also encouraged active participation and the ability to formulate explanations based on evidence, stands out.

Another widely valued strategy was the implementation of interactive simulators, such as those developed by PhET, which allow virtual experimentation with complex phenomena, modifying variables and observing their effects in real time. These tools are especially useful in contexts where material resources are limited or where it is necessary to complement the physical experience with visual representations that are difficult to observe directly (Wieman et al., 2020; Gómez-Vargas & Herrera, 2022).

Likewise, several studies pointed out the benefits of carrying out pedagogical outings to the natural environment, where students can directly observe physical phenomena such as free fall, sound, the effect of sunlight or the force of the wind. These activities, if guided by key questions and structured observation tasks, foster the development of scientific thinking and the connection between school knowledge and everyday life (Sánchez-Villavicencio et al., 2021; Pineda & Delgado, 2020).

Successful experiences of school inquiry projects were also reviewed, such as science fairs, construction of devices or resolution of physical challenges, which strengthen competencies such as collaborative work, creativity and autonomy in learning. In these contexts, students not only apply physical concepts, but also develop communication skills and abilities to argue and justify their decisions (Carrillo & Guzmán, 2021; López & Cabrera, 2022).

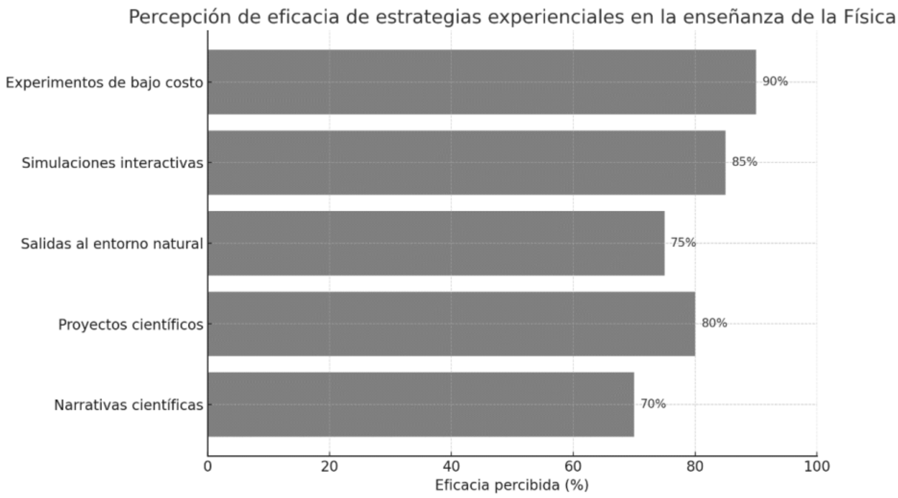

Figure 1. Perception of effectiveness of experiential strategies in physics teaching.

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The following table presents a synthesis of the main experiential strategies identified in the reviewed studies, their most relevant benefits and some of the sources that support them:

Table 1. *Experiential strategies in Physics teaching and their benefits.*

Experiential strategy	Observed benefits	References
Low-cost experiments	Facilitate the understanding of abstract concepts and foster interest.	Pavón et al. (2021); Martínez et al. (2020); Carrillo & Guzmán (2021)
Interactive simulations (PhET)	Improve the visualization of complex phenomena and allow autonomous learning.	Wieman et al. (2020); Gómez-Vargas & Herrera (2022)
Outings to the natural environment	Link physics with the everyday environment, encourage scientific observation.	Sánchez-Villavicencio et al. (2021); Pineda & Delgado (2020)
School science projects	Develop critical thinking and collaborative skills.	López & Cabrera (2022); Cevallos et al. (2022)
Science narratives with experimentation	Motivate active participation and connect physics with language and creativity.	García-Sancho et al. (2021); Salas & Montenegro (2021).

Taken together, the results indicate that the experiential approach is not only feasible from a methodological point of view, but also effective in improving the quality of learning in physics. The strategies analyzed show a high potential to be adapted to diverse school contexts, including those with infrastructure or material limitations. Their implementation does not necessarily require large resources, but rather a pedagogical commitment on the part of the teacher and creative planning that considers the student's environment as a source of learning.

Conclusions

The analysis developed throughout this article allows us to reaffirm that the experiential approach in the teaching of physics represents a relevant, effective and adaptable pedagogical alternative to the school contexts of General Basic Education. Far from being a simple methodological strategy, this approach constitutes an educational philosophy that recognizes students as active subjects in the construction of knowledge, and experience as the privileged means to establish meaningful relationships with scientific content.

One of the main contributions of this review is the recognition that physics can and should be taught in a concrete way from the first educational levels, overcoming the traditional view that reserves it for higher levels or that presents it as an abstract, mathematical discipline far from everyday life. The studies reviewed agree that children have an innate capacity to ask questions about the physical world that surrounds them, and that this curiosity can be channeled productively if the teaching offers opportunities to observe, experiment, construct and discuss real, close and understandable phenomena.

It has also been shown that the use of low-cost materials, field trips, school projects and digital simulators are powerful tools for implementing the experiential approach even in contexts with limited resources. This is especially important in Latin American countries such as Ecuador, where many schools lack laboratories or specialized equipment, but have committed teachers and natural environments rich in educational possibilities. In this sense, the experiential approach democratizes the teaching of physics, showing that large investments are not necessary to achieve significant learning, but rather creativity, planning and pedagogical will.

From the curricular point of view, this approach is also aligned with the principles of the Ecuadorian national curriculum, which promotes the development of scientific competencies, active learning and the integral formation of the student. Teaching physics from experience allows developing not only conceptual knowledge, but also skills such as systematic observation, logical thinking, hypothesis formulation, argumentation, scientific communication and teamwork. These competencies are key not only for academic success, but also for the formation of a critical citizenry, capable of making informed decisions and understanding the natural phenomena that affect their daily lives.

Another relevant aspect of the conclusions is the transforming role of the teacher in the implementation of this approach. Far from being a

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simple transmitter of information, the teacher becomes a mediator of experiences, a guide who facilitates the construction of knowledge through dialogue, experimentation and reflection. This role requires an investigative attitude, a willingness to innovate and a solid didactic training in natural sciences. Therefore, it is recommended that educational institutions and teacher training programs incorporate the experiential approach more systematically in their curricula, both at the initial level and in continuing education.

Furthermore, it is noted that the experience should not be limited to a specific activity, but should be coherently integrated into curricular planning. To this end, it is necessary to create conditions that allow teachers to plan ahead, to have adequate materials available and to evaluate learning in a diversified manner. The implementation of portfolios, qualitative rubrics, field diaries and formative evaluations are valid alternatives to assess complex processes such as experimentation, observation, discussion and continuous improvement. Evaluating physics from experience also implies valuing deep understanding, the ability to apply knowledge and scientific attitude, above the memorization of formulas or definitions.

In relation to the results obtained in the review, it is highlighted that empirical studies show significant improvements in academic performance, in the attitude towards physics and in the development of scientific skills when experiential strategies are applied. In particular, research that includes low-cost practices, such as those reported by Pavón et al. (2021), show that these types of proposals are especially effective in highly vulnerable school contexts, where meaningful experiences are scarce and access to educational resources is limited. These experiences also contribute to reducing gender and achievement gaps by actively involving all students, regardless of their previous level of knowledge.

It is also concluded that the experiential approach strengthens the link between physics and other areas of knowledge. By integrating scientific narratives, games, literature, art or technology, students can build a more integrated and contextualized view of physical phenomena, understanding that science is not an isolated discipline, but a way of understanding the world that dialogues with multiple knowledge and languages. This interdisciplinary perspective is consistent with current teaching approaches and can be a way to motivate students who might otherwise be indifferent or insecure about scientific content.

Finally, this review makes some pending challenges visible. Among them, the need for more local research that systematically documents successful experiences at the General Basic Education level; the urgency of educational policies that support pedagogical innovation with resources, training and support; and the importance of generating a school culture that values science as a living, relevant and formative experience from the first years of schooling. Overcoming these challenges is key to consolidate a physics education that not only informs, but also transforms the way students think, feel and act in relation to the natural world.

In conclusion, teaching physics as an experience is not a pedagogical luxury or an optional alternative, but an urgent educational need to achieve a more human, more active and more meaningful scientific education. The science classroom should be a space for exploration, discovery and collective construction of knowledge, where physics is experienced, questioned, understood and enjoyed.

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