Uisrael
REVISTA CIENTÍFICA

January – April 2025 Period
Vol. 12, No. 1
rcientifica@uisrael.edu.ec
https://doi.org/10.35290/rcui.v12n1.2025.1257 • e-ISSN: 2631 - 2786

Impact of experimental kits on science and practical skills training in chemistry students: a systematic review (2018-2023)

Impacto de los kits experimentales en la formación de habilidades científicas y prácticas en alumnos de química: una revisión sistemática (2018-2023)

Date of receipt: 2024-05-15 • Date of acceptance: 2024-10-16 • Date of publication: 2025-01-10

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Abstract

The study presents the main findings on the impact that experimental kits have had on the formation of scientific and practical skills in high school and university chemistry students through a systematic review following the phases of the PRISMA protocol. After a search and selection using inclusion and exclusion criteria, 18 studies selected from the Scopus, Google Scholar, and ERIC databases were analyzed. The results indicated that experimental kits facilitate observation, interpretation of results, proper handling of instruments, formulation of hypotheses, analysis of physical and chemical changes, as well as evaluation of quantitative and qualitative data, among others. In addition, socioeconomic factors such as inclusion in curricular planning are key determinants of the effectiveness and scope of experimental kits. In contexts where these aspects are adequately managed, a notable improvement in the quality of practical education was observed, contributing significantly to more enriching and effective learning. Concluding that experimental kits are effective resources for the training of practical and scientific skills, offering remarkable benefits thanks to their versatility, portability, safety, ease of use, and low maintenance cost.

Keywords: experimental kits, chemistry teaching, practical abilities, scientific abilities, laboratory kits

Resumen

El estudio presentó los principales hallazgos acerca del impacto que han tenido los kits experimentales en la formación de habilidades científicas y prácticas en estudiantes de química de secundaria y universitaria, mediante una revisión sistemática siguiendo las fases del protocolo PRISMA. Luego de una búsqueda y selección mediante criterios de inclusión y exclusión, se analizaron 18 estudios seleccionados de las bases de datos Scopus, Google Académico y ERIC. Los resultados señalaron que los kits experimentales facilitan la observación, la interpretación de los resultados, un adecuado manejo de instrumentos, formulación de hipótesis y análisis de cambios físicos y químicos, así como la evaluación de datos cuantitativos y cualitativos, entre otros. Además, factores socioeconómicos como la inclusión en la planificación curricular son determinantes claves en la efectividad y el alcance de los kits experimentales. En contextos donde estos aspectos se gestionan de manera adecuada, se observó una notable mejora en la calidad de la educación práctica que contribuye significativamente a un aprendizaje más enriquecedor y efectivo. Concluyendo que los kits experimentales son recursos eficaces para la formación de habilidades prácticas y científicas, ofreciendo beneficios notables gracias a su versatilidad, portabilidad, seguridad, facilidad de uso y su bajo costo de mantenimiento..

Palabras clave: kits experimentales, enseñanza de la Química, habilidades prácticas, habilidades científicas, kits laboratorio

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Introduction

Chemistry is essential for unraveling the mysteries of our environment, yet it often presents significant challenges in both teaching and learning. This can make the subject overwhelming and unappealing to some students, especially because this difficulty is compounded by their lack of practical skills.

On the other hand, acquiring knowledge in chemistry is greatly enhanced when students engage in practical activities. Therefore, it is crucial for educators to employ a variety of didactic strategies to capture students' interest and increase their motivation toward the subject.

In this regard, experimental kits (hereinafter referred to as EKs) have proven to be valuable tools at both the secondary (high school) and university levels. They play an important role in students' intellectual development by providing practical resources that help them understand chemistry concepts more effectively (Sandoval et al., 2013). These kits enable students to observe, measure, and interact with chemical phenomena in ways that would not be possible in a conventional laboratory.

According to Espinosa et al. (2016), students have shown a growing interest in studying chemistry due to experimental work, which allows them to understand chemical phenomena from both theoretical and practical perspectives. This integration facilitates the learning of procedural, conceptual, and attitudinal knowledge, promoting the development of scientific and practical skills. Unfortunately, practical work in education faces substantial challenges, largely due to misconceptions held by teachers regarding the usefulness of laboratory practices. According to Fernández (2018), this issue arises from educators' tendency to undervalue experimental practices, considering them an excessive investment of time, effort, and resources.

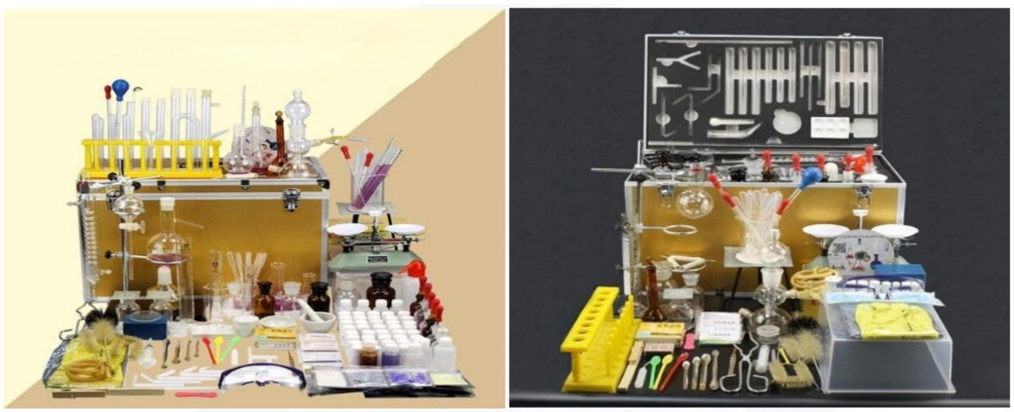
Even when classroom experiments are conducted, they are often limited to mere illustrative exercises that involve following instructions, leading to minimal competency development in students. Additionally, these experiments tend to lack clarity and effectiveness. Similarly, Zorrilla et al. (2020) indicated that this problem is also attributed to the lack or insufficiency of laboratory resources, as well as the absence of practical sessions. As a result, professionals are trained with strong theoretical knowledge but exhibit deficiencies in applying that knowledge in their professional practice.

In recent years, there has been growing interest in education regarding the role of EKs in developing students' scientific and practical skills. The COVID-19 pandemic and the expansion of virtual education have further highlighted the importance of EKs, as they allow students to conduct experiments without being physically present in a laboratory. In this regard, López and Tamayo (2012) stated:

"EKs can increase students' engagement and interest in chemistry, as experimental work fosters and promotes science learning. It encourages students to question what they are learning, allowing them to apply their knowledge and integrate it with experimental work" (p.147).

Figure 1

Experimental Kits Applied to Chemistry.



Nota. Images taken from Amazon.

On the other hand, Espinosa et al. (2016) indicated that incorporating practical work as a teaching-learning strategy facilitates the understanding of concepts, enabling students to analyze and evaluate the entire process to reach precise conclusions by applying scientific and practical criteria.

> Laboratory practices serve as learning spaces where students develop and acquire competencies, establish scientific criteria, verify theoretical concepts, and, most importantly, relate them to prior knowledge (Severiche & Acevedo, 2013, p. 193).

One of the advantages of EKs is their ability to materialize theoretical concepts through practical work, allowing students to understand and apply these concepts tangibly. This promotes a deeper comprehension of chemistry and helps students develop critical and analytical thinking skills, which are essential for success in various academic and professional fields. Additionally, studying chemistry requires students to develop cognitive and conceptual skills. Therefore, this study focused on the use of experimental kits in secondary and higher education levels, as these stages establish the foundation for understanding the scientific world.

Given this context, the present article aims to examine scientific evidence on EKs and their impact on the development of scientific and practical skills in chemistry students at different educational levels. In this regard, the following research questions were formulated:

1. What studies have been conducted on this subject?
2. At which educational levels are laboratory kits most commonly used?
3. What are the most frequently used terms in the reviewed studies?

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4. What scientific and practical skills do students develop when using experimental kits implemented by teachers?
5. What factors influence the implementation and management of experimental kits?

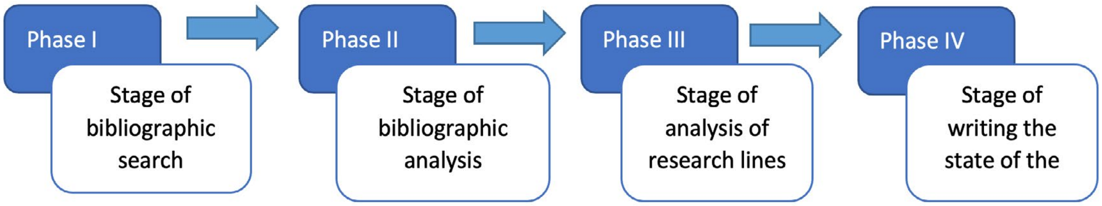
Methodology

This article is based on a systematic literature review and corresponds to an exploratory-descriptive study. According to Sánchez et al. (2022), this methodology aims to "identify, select, evaluate, and synthesize high-impact research evidence transparently and accessibly, responding to a clear and specific research question" (p. 52). The study was conducted following the guidelines of the PRISMA 2020 protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), with the purpose of exploring national and international studies on the integration of experimental kits and their impact on the development of scientific and practical skills in chemistry students.

Furthermore, Page et al. (2021) stated that a systematic review examines current bibliographic trends through a systematic process involving the collection, identification, selection, and evaluation of bibliographic data. This methodology was chosen due to the multiple advantages of systematic reviews, which allow the synthesis of current knowledge in a specific field. The review was carried out in the following phases:

Figure 2

Phases for Knowledge Interpretation.



Note. Phases adapted from León (2013)

Phase I: The heuristic method was employed, through which the "preparation, formulation, and collection of information" was carried out (Vinueza et al., 2022, p. 49). A search was conducted in the Scopus, Google Scholar, and ERIC databases using the following key terms: laboratory kit, experimental kit, educational kit, portable laboratory, chemistry, competencies, skills, practical, and scientific, which were connected using the Boolean operators AND and OR.

Phase II: At this stage, studies that did not meet the research objective were filtered out, leaving only those that would be analyzed in Phases III and IV. To ensure relevance, the following inclusion criteria were established:

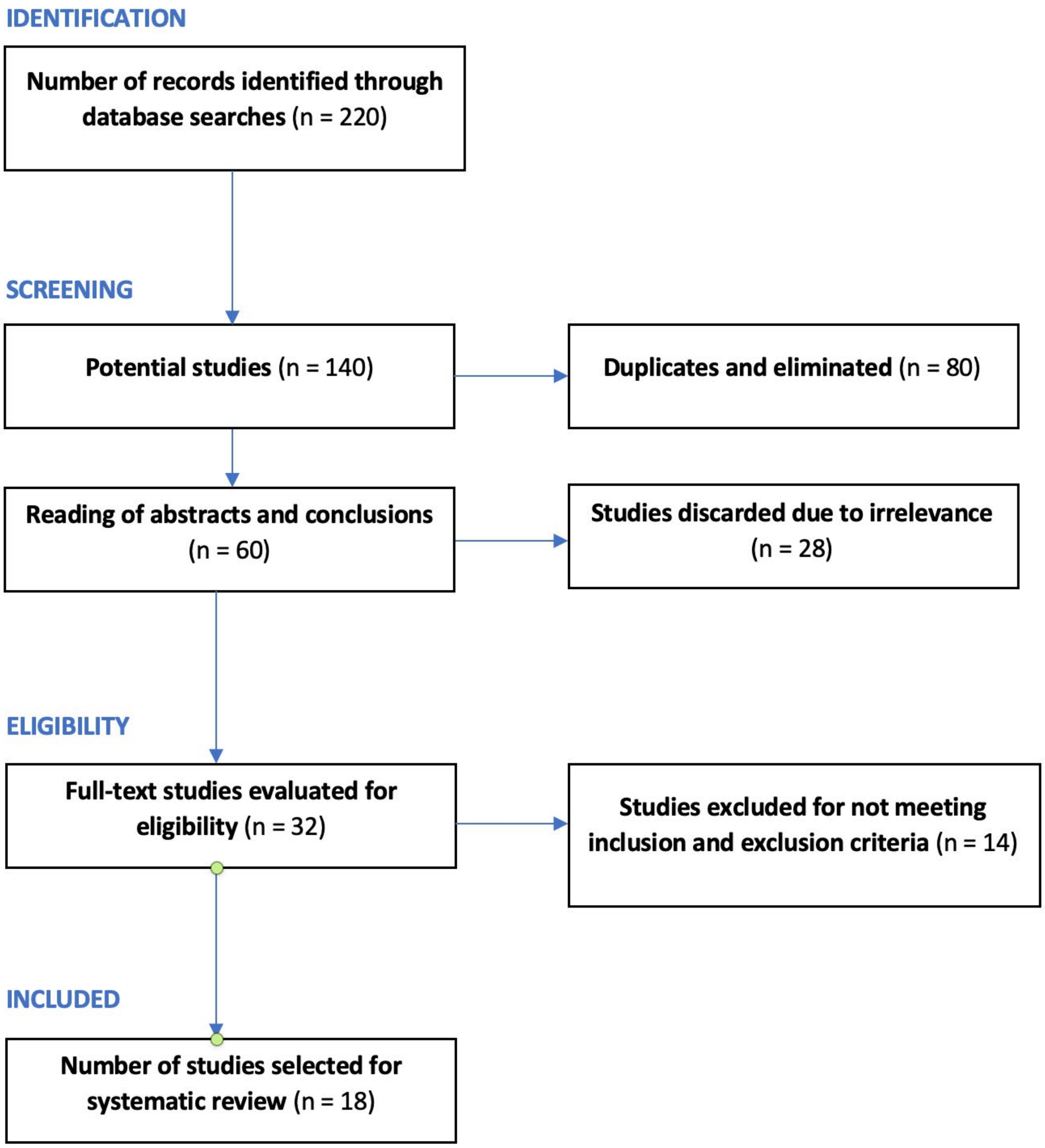
1. Studies published from 2018 onwards
2. Publications in English, Portuguese, or Spanish

3. Works that include experimental kits in Chemistry
4. Studies with a quantitative, qualitative, or mixed approach
5. Sources limited to articles, books, conference papers, and theses

Regarding exclusion criteria, studies that did not address the research topic or failed to meet the inclusion criteria were automatically discarded.

Figure 3

Presents the PRISMA Flow Diagram.



Note. PRISMA Flow adapted from Moher (2009).

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After a rigorous search, 32 studies were identified for potential evaluation. Of these, 14 studies were excluded because they did not match the search period, were in a different language, corresponded to systematic reviews, essays, narratives, or conference presentations, or were unrelated to the field of education. Although some of these studies addressed experimental kits, they were focused on other subjects, such as physics or biology. After this process, 18 publications were selected for the review.

Phase III: After completing Phases I and II, an individual review of the 18 studies was conducted to identify the most relevant concepts and key findings from the authors, incorporating our own analysis.

Phase IV: In the final stage, the hermeneutic method was applied to the 18 selected studies, where they were "interpreted, constructed, and theoretically represented" (Vinueza et al., 2022, p. 49).

Additionally, natural language processing (NLP) techniques such as word cloud generation and frequency diagrams were used to identify the most frequently appearing terms in the abstracts of the selected studies. To ensure consistency in the results, certain terms were standardized, including student/s; competencies/skills; student body, student/s; practical; chemical/s; kit/s; and scientific/s.

Results

Among the eighteen studies selected for review, the majority were fourteen scientific articles: Ambruso & Riley (2022), Amsen (2021), Andrews et al. (2020), Fuangswasdi et al. (2023), De Morais et al. (2021), Ibarra et al. (2020), Kelley (2021), Molina (2018), Nguyen & Keuseman (2020), Samuel (2021), Sukarmin et al. (2020), Toma (2021), Vizcarra Sánchez & Vizcarra Gavilán (2021), and Zohdi & Azmar (2023). Additionally, three published theses were included: Orrego (2020), Urquizo & Poma (2023), and Tejero (2020), along with one digital didactic book by Malanca & López (2020).

In *Figure 3*, the distribution of studies by year shows: seven studies in 2020, six in 2021, three in 2023, and two in both 2018 and 2022. Regarding the methodological approach (*Figure 4*), twelve studies used a quantitative methodology, five followed a qualitative approach, and one used a mixed-methods approach. In terms of educational level, nine studies focused on secondary education, while the other nine were applied at the higher education level.

Figure 4

Tracking of Published Studies by Year.

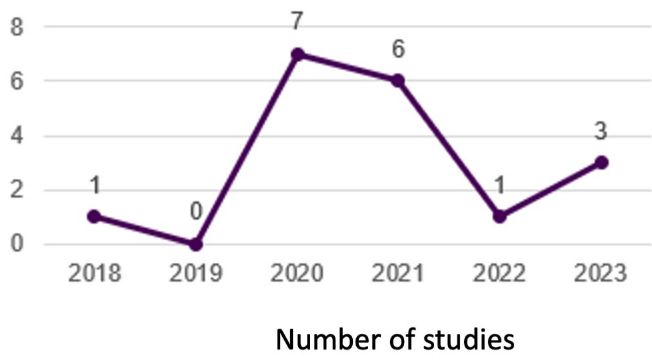
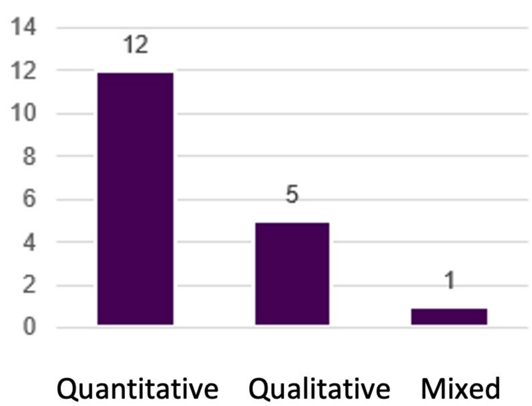


Figure 5

Number of Publications by Their Methodological Nature.



2.2. Geographical Mapping

Regarding the geographical distribution (*Figure 5*), it is observed that the United States has four publications, followed by Brazil, Ecuador, and Indonesia (with a total of six studies); Colombia, Peru, Mexico, Argentina, Spain, Thailand, and Poland (with a total of seven studies). It is also worth mentioning that no information was obtained regarding the country of origin for one study.

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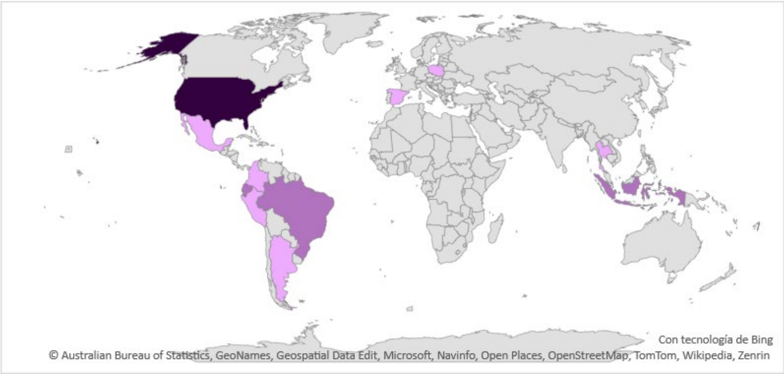
Figure 6

Scientific Production on the Use of Visual KE in Different Countries.

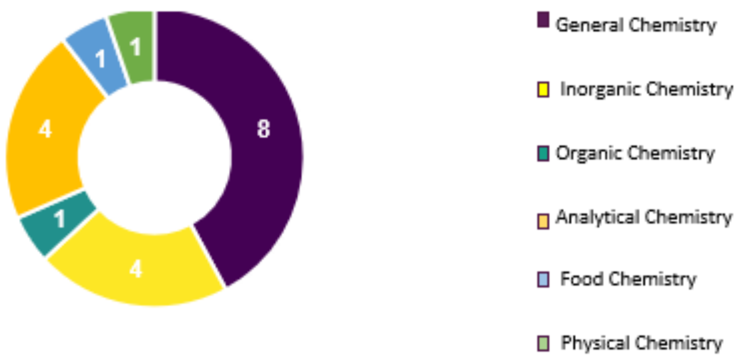


3.3. Distribution of Studies by Areas of Chemistry.

Out of the eighteen studies reviewed, all of them focus on the use of experimental kits, as each analyzed document is based on the use or development of an experimental kit. *Figure 5* details the frequencies, showing that most publications are related to the areas of General Chemistry (n = 8), Inorganic Chemistry (n = 4), Analytical Chemistry (n = 4), Organic Chemistry (n = 1), Physical Chemistry (n = 1), and one study on Food Chemistry (n = 1). It is important to note that some studies addressed more than one of these topics.

Figure 7

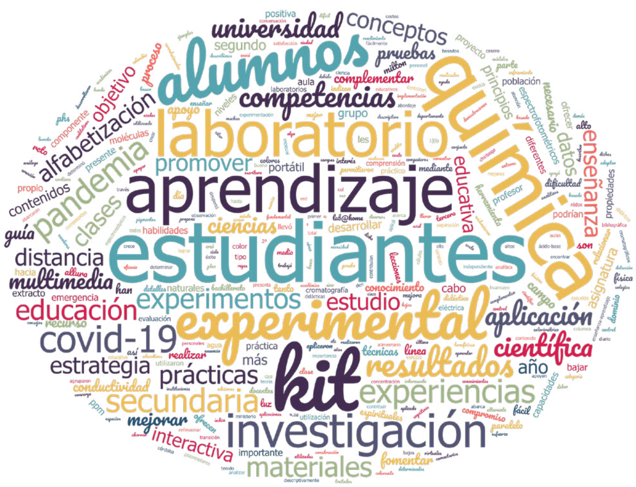
Number of Studies by Areas of Chemistry.



3.4. Frequency of Most Used Terms.

Figure 8

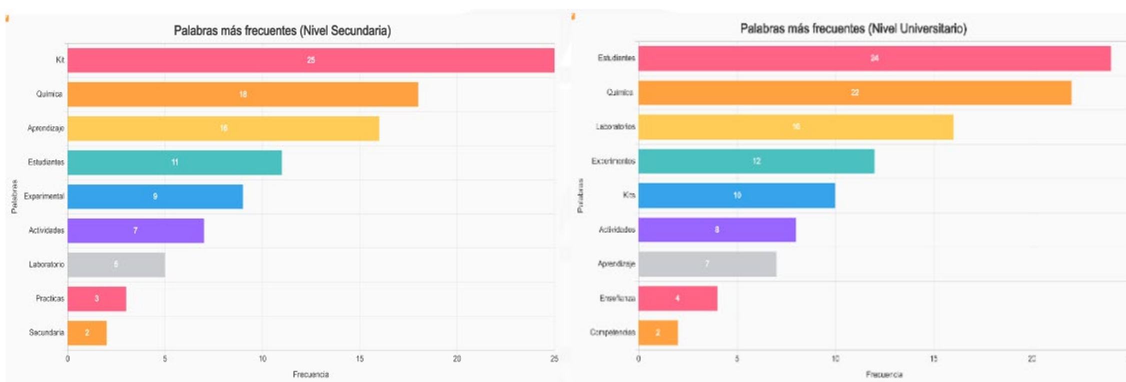
Word Cloud.



Nota: Created based on the abstracts of the reviewed studies.

Figure 9

Most Frequent Words by Educational Levels.



With the aim of identifying the frequency of terms, *Figure 6* highlights the most common words found in the abstracts, such as experimental kits and laboratory kits, along with terms like learning, Chemistry, students, competencies, practices, experimental, and scientific. Similarly, *Figure 7* allows for a comparison of the most frequently used terms at each educational level, confirming that the selection of documents was the most appropriate for the review.

3.5. Experimental Kits (KE) in Chemistry Education.

After analyzing the studies, the findings indicate that experimental kits (KE) can enhance students' motivation and interest in studying chemistry, which in turn leads to greater academic success.

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Additionally, KE foster skills such as problem-solving and critical thinking—key elements that facilitate the understanding of science by engaging students in hands-on experiments. This practical involvement allows them to explore and discover new concepts in the field of chemistry. In line with this, *Table 1* presents the most significant findings reported by the authors.

Table 1

Findings on Experimental Kits (KE) in Chemistry.

ID	Authors/Year	Findings
1	Fuangswasdi et al. (2023)	The use of the Lab@Home kit during the COVID-19 pandemic improved students' learning process more efficiently.
2	Andrews et al. (2020)	A significant improvement in General Chemistry learning was observed
3	Toma (2021)	The Chemistry kit had a significant impact on chemistry learning, with an increased student interest, resulting in better comprehension of the topics.
4	Kelley (2021)	The use of the experimental laboratory kit in a home setting proved to be suitable, easy to use, cost-effective, and safe. Additionally, it positively impacted student participation and knowledge acquisition in Organic Chemistry.
5	Ambruso y Riley (2022)	With the use of the home laboratory kit, students were able to discuss and better understand the analytical techniques implemented in the kit, while also reflecting on the
6	Amsen (2021)	The findings indicated that studying Chemistry using a laboratory kit in a remote learning setting presents several challenges. However, numerous methods and resources are currently available to overcome these challenges and strengthen students' knowledge.
7	Ibarra et al. (2020)	In the study, 80% of students successfully separated at least two primary colors through chromatography, demonstrating that experiments can be conducted at home using readily available resources.
8	Orrego y Paullán (2020)	The application of the practice kit increased students' interest in learning Chemistry, promoting cognitive skill development and improving their attitudes.
9	Tejero (2020)	The pH colorimetric kit allowed students to relate pH color changes to theoretical concepts covered in class.
10	Molina (2018)	The implementation of experimental kits improved students' attitudes—an important factor in enhancing Chemistry learning.
11	Sukarmin et al. (2020)	The findings show that the Chemistry kit is a practical route to obtaining valuable learning experiences, in addition to being cost-effective and easy to use for students. Even in virtual education, the kit provides a means for more practical learning and reinforces the hands-on nature of the subject.
12	Malanca y Lopez (2020)	The "*Teaching Science through Experiments*" kit aims to foster scientific knowledge in educational institutions through hands-on experiments. The manual included in the kit provides a wide range of experimental activities to enhance practical learning and skill development in Chemistry.
13	Nguyen y Keuseman (2020)	The study highlights the relevance of integrating experimental activities in the classroom and demonstrates that experiments can be safely conducted at home without the need to purchase expensive laboratory kits.
14	De Morais et al. (2021)	Activities carried out with the mobile water analysis kit (H2O) highlight the importance of experimental work in Chemistry. The results indicated that students were more motivated by the didactic strategy, leading to more meaningful learning.

15	Urquizo y Poma (2023)	The results show that the experimental kit positively impacts and improves Chemistry academic performance, while also motivating students to develop cognitive, scientific, and practical skills.
16	Vizcarra y Vizcarra (2021)	The implementation of a portable laboratory improved the academic performance of the experimental group (tc: 5.805, p-value < 0.01), demonstrating that the portable lab is a valuable resource that supports Chemistry learning and encourages systematic and contextualized study.
17	Samuel (2021)	Student learning increased following the intervention with the kit. Additionally, students reported that it was an effective tool for enriching their learning experience.
18	Zohdi y Azmar (2023)	The results indicated that the development of modules supported by the kit is highly beneficial in enhancing students' scientific skills. It also promotes psychomotor, cognitive, and spiritual outcomes for students.

3.6. Practical and Scientific Skills Acquired through Experimental Kits (KE).

According to Herrera and Córdoba (2023), the acquisition of skills "is fundamental in the new educational approach, referring to them as a set of abilities that teachers use to maximize their students' potential" (p. 4).

Martín et al. (2019) define a practical skill as the ability to design, conduct, and analyze experiments, using techniques and tools to collect empirical data through the proper handling of instruments and the rigorous execution of experimental procedures.

On the other hand, a scientific skill encompasses the ability to understand and apply theoretical principles and concepts in the scientific field, including hypothesis formulation, interpretation of experimental results, and communication of findings through scientific writing (García & Moreno, 2020).

Scientific Skills

- Interpretation of data obtained from experiments.
- Ability to follow instructions through experimental protocols.
- Accuracy and comprehension of results in experiments.
- Knowledge of laboratory safety rules.
- Skill in problem-solving and acting independently in a remote setting.
- Data processing, including the use of statistical tests.
- Understanding the phases of chromatography.
- Integration of chromatography theoretical concepts into practical experiments.
- Understanding the principles of separation and analysis through chromatography.
- Application of theoretical concepts in practical laboratory contexts.
- Observation of the stability of pigment solutions under different conditions, such as color variations and degradation over time.

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- Interpretation of collected data and extraction of conclusions from experimental results

Practical Skills

- Proper planning and design of experiments.
- Handling of laboratory equipment and application of experimental methods.
- Observation of chemical and physical changes in experiments.
- Analysis of qualitative and quantitative data using techniques such as fluorescence cooling, reverse-phase chromatography, absorption spectroscopy, and Brownian motion.
- Use of experimental methods to determine analyte concentrations in samples.
- Mastery of pipette handling, liquid pouring, and reading specialized equipment.
- Problem-solving in the laboratory when issues arise.
- Adaptation of laboratory techniques to different settings.
- Selection of materials and reagents for experiments.
- Application of extraction techniques to separate pigments.
- Interpretation of experimental results and formulation of questions.
- Application of laboratory techniques in a home setting.
- Presentation of results and procedures through laboratory reports.
- Adaptability to conduct scientific experiments without access to specialized equipment or instruments.

3.7. Factors Associated with Implementation.

Socioeconomic Factors

According to Agualongo and Garcés (2020), the socioeconomic factor in both developed and developing countries affects education quality in various ways, including low enrollment rates, academic achievement, and high dropout rates.

Regarding design, the costs of production and maintenance vary significantly depending on the type and complexity of each kit. In terms of costs, countries such as the United States, Ecuador, Peru, and Brazil acknowledge the efforts of educators in developing Experimental Kits (KE), which require purchasing equipment, instruments, materials, and necessary reagents—expenses that can be significant for advanced or specialized kits. Figures 8A and 8B illustrate some examples of KE that required financial resources for their development.

In contrast, in countries such as Colombia, Argentina, and Ecuador, some kits have been made using easily accessible materials found in supermarkets or pharmacies (Figures 8C and 8D). Examples include everyday reagents such as salt (NaCl), sugar ($C_{12}H_{22}O_{11}$), baking soda ($NaHCO_3$), alcohol (both ethyl and pharmaceutical), hydrogen peroxide, drain cleaner (NaOH), plant extract indicators, plastic cups, bottles, containers, droppers, and other common items.

Figure 10

Examples of Experimental Kits Observed in the Studies.

a. Laboratorios portátiles Vizcarra y Vizcarra (2021) **b.** Kits experimentales Urquizo y Poma (2023) **c.** Laboratorios portátiles Molina (2018) **d.** Kits experimentales (Química), Fuangswasdi et al. (2023)

Additionally, maintenance involves ongoing expenses to replace worn components, replenish consumables, and make necessary repairs to ensure that the equipment functions properly. These costs can increase over time, especially if the kits are frequently used by large groups of students. Furthermore, schools may need to invest in teacher training to ensure the proper and safe use of KE, adding another layer of costs.

The combination of these factors can represent a significant financial burden for educational institutions with limited resources, affecting their ability to provide high-quality, hands-on education equitably.

Educational Plans

Several factors can affect the efficiency of KE in the teaching process, including:

- Resistance to change from teachers and school administrators.
- Lack of financial and technological resources.
- Differences in teacher training and professional development.
- The challenge of adapting curricula to local contexts while meeting standardized educational policies.

In Colombia and Mexico, despite government efforts to incorporate KE into public schools, these programs often struggle with sustainability and accessibility due to a lack of funding and ongoing support. These challenges are more pronounced in economically disadvantaged areas, where structural limitations and the digital divide hinder equitable implementation of pedagogical innovations (Meroni et al., 2015).

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For example, in Peru, Vizcarra Sánchez and Vizcarra Gavilán (2021) highlighted that their study identified a lack of laboratories and resources, making it impossible for students to develop experimental skills. As a result, teachers are limited to theoretical instruction, without the practical component. Similarly, in Ecuador, Urquizo and Poma (2023) found that limited laboratory practices and the absence of a fully equipped physical laboratory restrict students from strengthening their practical skills and competencies. This limitation hinders experimental learning, making chemistry seem like a monotonous and difficult subject.

In contrast, in countries like the United States and Poland, the implementation of KE is more aligned with established educational plans due to greater financial resources. In the United States, schools have larger budgets and specific funding programs that facilitate the acquisition and maintenance of KE, as well as continuous teacher training for their proper use.

Poland, although it does not have the same level of resources as the United States, has successfully integrated KE into its educational system through well-structured educational policies and a focus on modernizing science teaching (Ponce, 2010).

These examples highlight the importance of considering the socioeconomic context and educational policies when evaluating the implementation of KE, as they directly influence the quality and equity of practical science education for students.

Findings and Conclusions on Experimental Kits (KE)

The results showed that experimental kits are ideal resources for fostering the development of practical and scientific skills, providing a relevant and meaningful learning experience. These kits not only help students understand theoretical concepts but also enable them to apply them in practical processes. These findings support the idea proposed by Veitia et al. (2022) that the integration of experimental work provides a solid foundation for carrying out concrete actions, analyzing data, evaluating hypotheses, and planning experiments—ultimately enhancing scientific knowledge and learning.

This approach offers a more contextualized learning experience, better preparing students to tackle future scientific challenges. Our findings align with those of Molina et al. (2016) and Martin et al. (2019), who emphasized the importance of experimental kits in the development of practical skills for studying science, particularly chemistry. These resources facilitate the acquisition of skills such as:

- Measuring volumes
- Designing and assembling equipment
- Identifying substances
- Separating compounds based on their chemical and physical properties

Through this systematic review, it is evident that KE play a crucial role in education. According to Dickerson et al. (2014), using these kits can enhance students' understanding of scientific phenomena and chemical concepts, as well as improve their academic performance through exploration, experimentation, and critical thinking.

Similarly, Foley et al. (2013) stated that integrating KE enhances student motivation and interest in learning chemistry. By actively participating in experiments and observing the results of their investigations, students experience greater success and curiosity, making their learning process more engaging and enriching.

Additionally, Kennepohl (2007) argued that the at-home experience with KE is comparable to traditional laboratory experiences. Urquizo & Poma (2023) and Vizcarra Sánchez & Vizcarra Gavilán (2021) also highlighted that KE are feasible tools for teaching as they complement classroom instruction and motivate students by improving cognitive and practical skills.

However, financial barriers remain a challenge for educational institutions. To ensure equal access, institutions should consider solutions such as:

- Government subsidies
- Partnerships with non-governmental organizations (NGOs)
- Creating loan programs for experimental kits

This would ensure that all students, regardless of their economic background, can benefit from these valuable learning tools. Moreover, it is crucial to promote investment in science education at the political and community levels to bridge resource gaps and make KE accessible to all students, rather than limiting them to well-funded institutions (Arjona et al., 2022; Bonilla et al., 2022).

In light of these challenges, strategic approaches tailored to the realities of developing countries are proposed. These include:

- Public-private partnerships to fund the acquisition of kits
- Continuous training programs for teachers
- Adapting KE to locally available resources

Such strategies aim to ensure that all students, regardless of their socioeconomic status, have access to a high-quality practical education, enabling them to develop strong scientific skills (Bonilla et al., 2022).

Conclusiones

Valuable information was gathered on laboratory kits, confirming that they are essential resources for acquiring practical and scientific skills. These skills include:

- Handling laboratory instruments and equipment
- Employing experimental techniques

- Managing chemical substances
- Observing chemical and physical changes in experiments
- Analyzing qualitative and quantitative data
- Applying methods to identify analytes
- Adapting and applying experimental techniques in non-traditional settings (e.g., at home)
- Following experimental instructions and protocols
- Ensuring precision and comprehension of experimental results
- Fostering scientific curiosity and investigative skills in students

In the 18 studies reviewed between 2018 and 2023, laboratory kits were found to significantly contribute to educational advancement by developing both practical and scientific skills in students. Most studies focused on areas such as physical chemistry, organic chemistry, and food chemistry. The most frequently used terms identified in the research were: Chemistry, experimental kit, laboratory kit, students, skills, practical, and scientific. Additionally, it was determined that half of the studies were conducted in higher education, while the other half focused on secondary education (high school).

The implementation of experimental kits (KE) in educational settings has been deeply influenced by socioeconomic factors and educational planning. The reviewed studies highlighted that the costs associated with the creation, maintenance, and teacher training for KE vary significantly depending on the country and its level of economic development.

- In developed countries like the United States, the availability of financial resources facilitates the integration of KE into educational programs, contributing to a high-quality, practical education.
- In developing countries or those with limited resources, such as Colombia, Peru, and Ecuador, financial constraints and inadequate infrastructure hinder the effective implementation of KE, resulting in a more theoretical and less practical education, which negatively impacts learning quality.

Finally, experimental kits stand out for their versatility, as they can be adapted to a wide range of experiments and activities, enhancing the learning experience. Their portability allows for use in any location, and their simplicity enables students to quickly familiarize themselves with experimental procedures and techniques. Furthermore, their low maintenance cost makes them an affordable alternative for educational institutions with limited resources, ensuring greater accessibility to hands-on scientific learning.

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e-ISSN: 2631 - 2786
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