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TDIC in Chemical Education: analysis of student perceptions and choices to improve Pedagogical Practice

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Abstract: This article analyzes, in light of students' perception and choice, Digital Information and Communication Technologies (DICT) as a possibility to improve pedagogical practice in chemistry. The research, through an open questionnaire applied to students of two undergraduate classes, was based on the choice and justification of students about DICT to teach chemistry. It was found that 50% of the students chose the same resources and that the choice of DICT to enrich the ways of teaching and learning chemistry is exotic and well-founded.
Keywords: Digital Information and Communication Technologies; Chemistry Teaching; Teacher Training.

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TDIC na Educação Química: análise das percepções e das escolhas discentes para a melhoria da Prática Pedagógica

Resumo: Este artigo analisa, à luz da percepção e da escolha discente, as Tecnologias Digitais da Informação e Comunicação (TDIC) como possibilidade de aprimorar a prática pedagógica em química. A pesquisa, via questionário aberto aplicado a alunos de duas turmas de graduação, deu-se a partir da escolha e da justificativa dos graduandos sobre TDIC para ensinar química. Percebeu-se que 50% dos graduandos escolheram os mesmos recursos e que a escolha das TDIC para enriquecer as formas de ensinar e aprender química é exótica e fundamentada.
Palavras-chave: Tecnologias Digitais da Informação e Comunicação; Ensino de Química; Formação de professores.

TDIC en la enseñanza de la Química: análisis de las percepciones y elecciones de los estudiantes para mejorar la práctica pedagógica

Resumen: Este artículo analiza, a la luz de la percepción y elección de los estudiantes, las Tecnologías Digitales de la Información y la Comunicación (TDIC) como posibilidad de mejora de la práctica docente en Química. La investigación, a través de un cuestionario abierto aplicado a estudiantes de dos cursos de licenciatura, se basó en la elección y justificación por parte de los estudiantes de las TDIC para la enseñanza de la química. Se constató que el 50% de los estudiantes de licenciatura eligieron los mismos recursos y que la elección de las TDIC para enriquecer las formas de enseñar y aprender química es exótica y bien fundamentada.

Palabras clave: Tecnologías digitales de la información y la comunicación; enseñanza de la química; formación del profesorado.

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1 INTRODUCTION

The creation and implementation of disciplines and activities to discuss digital information and communication technologies (DICT) in higher education in Brazil began to gain prominence in the 2000s. At that time, technological advances and the popularization of the Internet provided a favorable scenario for incorporating DICT in education, including higher education (Schuartz; Sarmento, 2020; Anjos; Silva, 2018). With the increased access to DICT, higher education institutions began to recognize the importance of promoting the training of teachers and students for the effective use of technologies in pedagogical practices (Oliveira; Moura, 2024). From then on, several universities began to create and offer disciplines, extension courses, and training activities focused on the discussion and use of DICT in education.

These disciplines and activities address the use of digital tools in teaching and learning processes, the development of technological skills, the creation of digital educational materials, and the use of virtual learning environments and online teaching platforms, among others. Discussions on DICT in higher education in Brazil continue to evolve and adapt to current educational and technological needs. The process of integrating DICT into the academic context is dynamic and requires constant updating of pedagogical practices and educational methodologies to take full advantage of the potential of DICT to improve the quality of higher education (Sales; Moreira, 2022).

It is interesting to note that this text intends to mention a specific experience of the discipline of Teaching Practice I, within the framework of the Postgraduate Program in Science and Mathematics Education of the Federal University of Paraná (UFPR). In this context, the text worked as a teacher trainer in the undergraduate course in the discipline Instrumentation for Teaching Chemistry I, which is aimed at students of the Chemistry Degree course and is optional for students of the Bachelor's degree. This discipline is important in addressing the conceptual, procedural, and attitudinal dimensions that are fundamental in the teaching of chemistry, as they allow the content to be discussed in a more complete and meaningful way for students.

These dimensions are related to the pedagogical principles and types of activities used by the teacher to promote the learning of chemistry students. Therefore, the general objective of this discipline is to improve the skills and abilities related to the practical knowledge of the

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chemistry teacher, taking into account the theoretical foundations of chemistry and the science of education, through the implementation of educational actions in the school environment. The focus is on promoting creativity and innovation in the teaching of chemistry, including the development of effective pedagogical practices and the identification of innovative strategies to engage students (Souza, 2011; Vieira et al., 2019; Novais; Marcondes, 2008; Coelho; Paula, 2012).

Therefore, it is understood that ICT is one of the topics addressed and indispensable in teacher training and for improving teaching and pedagogical practices. Therefore, this article aims to describe and analyze ICT in the teaching of chemistry, as a way to improve the pedagogical practices of undergraduate students in chemistry and promote more qualified training of future teachers in the field, based on the organization of an intervention activity planned by undergraduate students, in which they present technological resources applied to the teaching of chemistry.

In terms of methodology, the study was conducted in two groups of undergraduate chemistry students, with classes taught in two different periods, afternoon and evening, with a total of 16 participants. A mixed methods approach was used, combining the practical application of educational technologies in chemistry teaching with an open-ended questionnaire to explore students' perceptions and experiences. This type of approach, in which ICTs are used as pedagogical resources in higher education, is relevant to improve students' technological skills, as well as to prepare them for the use of technologies in their future careers as teachers (Delamuta; Assai; Sanchez Júnior, 2020; Mata; Silva; Mesquita, 2021; Pereira, 2022).

In addition, the experience reported in the article can serve as a valuable guide for other educational institutions seeking to integrate ICT into their academic curricula. According to Marroni, Miranda and Carvalho (2022), the ability to use the available digital technological resources strategically, carefully and responsibly has become essential in today's society, and according to Siqueira and Bedin (2023), they add that teacher training provides digital competence, considered one of the most important of this century, fundamental for innovation, progress and the exercise of citizenship in the current context.

2 THEORETICAL FRAMEWORK

The development of DICT has brought about profound changes in society, especially in

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education. DICT encompasses a wide range of digital tools and resources such as computers, the Internet, educational software, mobile applications, virtual learning environments, and simulation technologies that have the potential to transform teaching and learning processes. Thus, the incorporation of DICT in education enables the creation of more dynamic, interactive, and adaptable learning environments to students' needs, as it promotes the personalization of education, allowing learning to take place at a pace and in a manner that best suits students' profiles (Afonso; Silva; Bedin, 2024).

In addition, DICTs contribute to the democratization of access to knowledge, making educational resources available to a wider audience regardless of their geographical location (Moran, 2015; Afonso; Silva; Bedin, 2024). Lévy (1999) argues that the virtualization of knowledge provided by DICT not only expands access to information, but also transforms the way knowledge is produced, shared, and applied. In education, this transformation implies that educators and students need to develop new skills to interact effectively with DICT (Pereira; Henriques, 2021).

In chemistry education, DICT plays a crucial role by providing resources that facilitate the understanding of abstract and complex concepts. According to Prado and Valente (2002) and Pauletti et al. (2017), computer simulations, virtual laboratories, and molecular modeling allow students to visualize and manipulate chemical phenomena interactively, resulting in deeper and more meaningful learning.

These technological resources allow students to explore scenarios that would be infeasible or dangerous in a physical laboratory, providing a richer and safer learning experience. In addition, the use of DICT in chemistry education promotes the development of analytical and critical skills as students are encouraged to test hypotheses, analyze data, and draw conclusions based on their interactions with simulations and virtual models. In addition, Silva (2022) emphasizes that the use of digital technologies in chemistry education not only facilitates the understanding of theoretical concepts but also improves the practical application of this knowledge.

Tools such as augmented reality applications, interactive videos, and e-learning platforms allow students to actively participate in the learning process, making the study of chemistry more accessible and attractive. Therefore, chemistry teacher education should incorporate DICT to prepare future educators for the challenges of teaching in the 21st century. Kenski (2012) and Silva (2023) argue that in initial teacher training, it is essential that courses

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include not only the development of technical skills to use DICT but also pedagogical skills to effectively integrate these technologies into the teaching and learning process.

In this sense, teacher training needs to go beyond simple training in the use of technological tools; future educators need to develop a critical understanding of the potential and limitations of DICT, as well as how these technologies can be used to promote innovative and inclusive pedagogical practices (Siqueira; Bedin, 2023). The integration of practical activities using DICT into the curriculum of Chemistry undergraduate courses can play a fundamental role in the preparation of future teachers, given that these activities allow undergraduates to experiment with different pedagogical approaches, such as project-based teaching and collaborative learning, which are facilitated by the use of DICT.

Practical experience in the use of these technologies during initial training can therefore contribute to the development of an investigative and innovative attitude in future chemistry teachers. Furthermore, the use of digital resources in academic activities allows chemistry students to experiment with and implement different pedagogical strategies, such as the use of simulations to demonstrate chemical reactions or the creation of virtual laboratories for controlled experiments. These practices contribute to the development of active pedagogical skills that are essential for teaching chemistry in an increasingly digital world.

Considering that DICTs have the potential to increase student engagement by making learning more interactive and personalized, Reigeluth (2013) states that digital technologies can transform traditional teaching into a more engaging experience in which students take an active role in constructing their knowledge. In chemistry classrooms, this could mean using simulation software to explore the properties of chemical compounds or mobile apps to review concepts interactively. Finally, DICTs play a critical role in promoting digital inclusion and expanding access to quality education by making learning more accessible to all students, regardless of location or socioeconomic status.

3 METHODOLOGY

This article describes a study conducted in the Instrumentation for Teaching Chemistry I course, which involved two classes taught at different times (afternoon and evening) with a total of 16 participating students. A specific activity was selected as a sample for analysis. In this activity, the students were asked to freely present an educational technology used in

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teaching chemistry, demonstrating its practical use for the class. However, it happened that out of the 16 participating students, 8 of them presented the same educational technology; the coincidence happened because they were from different classes (Kahoot, Wordwall, Socrative, Quizziz).

In addition to the hands-on presentation of educational technology, an open-ended questionnaire was used. This questionnaire aimed to gather detailed information about the students' understanding of educational technologies, as well as their perceptions of possible improvements in teaching and learning processes through the use of these technologies. Questions related to the pedagogical implications of DICT were also addressed.

Another important aspect to be presented is the privacy of the participating students, which is an ethical and important practice in academic research. Therefore, identifiers such as "Student Participant 1 (SP)", "Student Participant 2", and so on, were used as a common approach to maintain the anonymity of the participants while allowing for clear references during the presentation of the data. In addition, the description of the participants' characteristics (Table 1) adds a valuable layer of context to the study, as these details help to better understand the diversity of the participants and how it may influence the research findings.

Chart 1 – Description of the characteristics of the participating students

ID	Gender	Age	Period	Studied subjects focused on TDIC	TDIC presented
EP1	Male	30 years	7th period	No	EclipseCrossword
EP2	Female	24 years old	8th period	No	Kialo Edu
EP3	Male	21 years old	7th period	No	MindMeister
EP4	Male	29 years old	10th period	No	PhET Colorado
EP5	Female	23 years old	7th period	Yes	Puzzle.org
EP6	Male	36 years old	8th period	No	Quizlet

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EP7	Male	30 years	6th period	No	Chemistry Quiz
EP8	Male	25 years	8th period	No	ChemistryMaster
EP9	Male	22 years old	9th period	No	Wordwall
EP10	Female	21 years old	7th period	No	Wordwall
EP11	Male	21 years old	6th period	No	Socrative
EP12	Female	23 years old	7th period	Yes	Socrative
EP13	Female	22 years old	7th period	No	Quizziz
EP14	Male	25 years	8th period	No	Quizziz
EP15	Female	23 years old	10th period	No	Kahoot
EP16	Female	19 years old	3rd period	No	Kahoot

Source: Prepared by the Authors (2024)

According to the data in Chart 1, we can see that 9 students are male and 7 are female. Regarding the age group, 9 students are between 19 and 23 years old, 3 are between 24 and 28 years old, and 4 are over 29 years old. Regarding the academic period, 1 student was in the 3rd period, 2 participants were in the 6th period, 6 students were in the 7th period, 4 in the 8th period, 1 in the 9th period, and 2 in the 10th period.

It is also important to note that only 2 of the 16 participants had courses that focused on ICT. This suggests a possible pattern in undergraduate curricula, particularly in chemistry, where these courses are not widely offered or are optional, but this is not the purpose of this article. The information described in Chart 1 helps to paint a more complete picture of the students involved in the research, especially when considering the technologies chosen by each participant. The diversity of age and academic level influences the perceptions and experiences with the educational technologies presented. In addition, the gender balance may be relevant as there may be differences in preferences and learning approaches to ICT.

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4 RESULTS AND DISCUSSION

DICT has indeed had a transformative impact on teaching and learning when integrated into the pedagogical practices of teachers. The incorporation of DICT into the educational environment has fundamentally changed the way educators approach teaching and how students participate in the learning process, as the integration of DICT offers a variety of benefits such as increased access to educational resources, personalized learning, student collaboration, development of essential digital skills, and improved engagement. By engaging students more actively and using tools they are familiar with, teachers can create more dynamic and relevant learning environments.

Undergraduate students in initial training need to have experience with extracurricular activities or subjects focused on technological education (Brasil, 2013; Mello, 2000; Gatti, 2010). This is important to prepare future educators to effectively integrate ICT in their future pedagogical practices in the classroom. By understanding not only the pedagogical aspects but also the technical elements behind the technologies, teachers will be better prepared to face the challenges of teaching in the 21st century (Siqueira; Bedin, 2023), especially with digital literacy, as these "also constitute an important tool in the definition of digital education and lifelong learning policies at local, regional or national levels" (Marroni; Miranda; Carvalho, 2022, p. 20, translated by us).

Teaching processes and knowledge related to the technical elements involved in the systems that make technologies work are essential for educators to be able to select, use, and adapt technological tools appropriately to their students' needs and pedagogical objectives. This promotes a more meaningful integration of DICT into the educational context, resulting in more effective teaching and engaging learning.

The focus of this article is to present the use of DICT by students during the presentation in the discipline "Instrumentation for Teaching Chemistry I", highlighting the pedagogical possibilities that DICT offers in the teaching and learning processes in the field of chemistry. In this context, students are encouraged to explore and apply DICT in their presentations related to the discipline of chemistry.

EclipseCrossword is a tool that allows you to create and solve interactive crossword puzzles that include key terms and concepts covered in

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class, such as elements of the periodic table, types of chemical reactions, or nomenclature of compounds, and its use in education can bring several benefits to students and teachers. It is important to note that EclipseCrossword should be used as a complementary tool in the classroom, integrated into broader pedagogical strategies. In addition, it is important to ensure that the creation of the puzzles is aligned with the educational objectives and the level of knowledge of the students so that the learning experience is effective and meaningful. EP1 highlights that "one of the pedagogical possibilities of the tool is to present and review concepts".

EP2 includes the Kialo Edu online platform designed to facilitate constructive and collaborative debate. This tool can be used in education, especially in environments that value the discussion of ideas, critical analysis, and collaborative learning. For example, teachers can create debates on controversial and timely topics such as the use of genetically modified organisms in food production, the environmental impact of plastics production, or the ethics of using nuclear energy, among others. However, it is important to emphasize that the effectiveness of using Kialo Edu depends on its proper integration with pedagogical objectives, teacher preparation, and student engagement (Araújo; Barros, 2019). The platform may be particularly useful for subjects that emphasize critical analysis, informed decision-making, and the development of argumentation skills. EP2 believes that "to improve the learning process, the teacher must organize and ensure that all students have to discuss a given topic in the field of chemistry".

MindMeister is an online mind-mapping tool that allows you to create visual diagrams to organize ideas, information, and concepts. This tool has several applications in education and can be used in a variety of ways to enhance teaching and learning. However, it is important to remember that effective use of MindMeister in education requires proper planning and alignment with educational goals. Teachers should guide students in creating clear and coherent mind maps and ensure that the tool is meaningfully integrated into the learning process (Tavares, 2008). EP3 asserts that "organizing information, especially in a visual way, can facilitate learning. EP3 illustrates that teachers and students can create mind maps that illustrate the different steps of a chemical reaction, including reactants, products, catalysts, and the conditions necessary for the reaction to occur.

EP4 reports on the experience with PhET Interactive Simulations, also known as PhET Colorado, which is a collection of interactive HTML5 simulations developed by the University

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of Colorado, Boulder. These simulations cover a variety of science topics including physics, chemistry, biology, and mathematics. They have great potential to enrich education by making abstract concepts more tangible and enhancing student understanding. EP4 adds that this tool is a "virtual science laboratory that encourages students to think and learn critically". In chemistry education, for example, PhET Colorado simulations can facilitate the understanding of chemical reactions, including the conservation of mass, stoichiometric ratios, and the concepts of limiting reagent and excess, as well as help students understand chemical bonding, molecular geometry, and interactions between atoms, which are essential to understanding molecular chemistry, among other topics.

The use of PhET Colorado simulations in education requires proper planning on the part of educators to ensure that simulations are effectively integrated into the curriculum and learning objectives. In this sense, EP4 states that "Dynamics as an asset provides the teacher and student with a new tool to clarify and facilitate understanding of the content being covered. This includes guidance on how to use simulations, the design of targeted activities, and discussions to promote deeper conceptual understanding (Falchi; Fortunato, 2018).

Another tool introduced by EP5 is puzzel.org, an online platform that allows you to create and share interactive puzzles and activities such as crosswords, word searches, number puzzles, and more. This platform can be a useful tool in education, providing engaging ways to engage students, promote active learning, and review concepts. The effectiveness of using puzzel.org in education depends on how it is integrated with learning objectives and pedagogical strategies; proper planning and alignment with the curriculum are essential to ensure that activities are relevant and beneficial to students.

In the pursuit of learning, EP5 states that the tool "allows students to make connections with what they have seen in the classroom", thus enabling "knowledge retention". Puzzel.org, through its numerous pedagogical potential applied to the teaching of chemistry, allows teachers to create quizzes with questions about chemical elements, periodic tables, reactions, or laws of chemistry. They can also create puzzles that require students to match chemical symbols with their names or properties or develop memory games that require students to match reagents with their products in chemical reactions.

EP6 introduces Quizlet, an online platform that provides a variety of tools and resources for creating, studying, and reviewing educational content using flashcards, games, and tests (Gomes et al., 2021; Franco, 2018). It is widely used in education to help students learn and

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retain information effectively. As such, it is a versatile tool that can be integrated into teaching and learning in a variety of ways. However, it is important to plan and align its use with pedagogical goals to ensure that it contributes significantly to student learning. Thus, EP6 shows possibilities for improving learning by presenting “concepts in a different way, gamification facilitating student interest and learning”. Regarding the benefits about teaching chemistry, students can review and test their knowledge practically and quickly, helping them memorize elements, chemical formulas, and important concepts.

In the same sense as quizzes, Chemistry Quiz refers to an approach that uses questionnaires or quizzes to focus on concepts and knowledge related to chemistry. These quizzes can be used as an educational tool to assess, review, and engage students in learning chemistry. It is important to design quizzes carefully and to align them with learning objectives and pedagogical strategies. Educators can create quizzes using online platforms or specialized quiz-creation tools. It is important to ensure that quizzes are challenging but accessible and that they provide students with an opportunity to apply their chemistry knowledge in a meaningful way. To this end, EP7 presents one of the pedagogical possibilities of the tool through the use of quizzes that help students retain the content. In other words, quizzes can be created to review specific topics such as atomic structure, chemical bonds, chemical reactions, and stoichiometry, among others. Another perspective is to use it as a formative assessment, allowing the teacher to continuously evaluate student progress, provide immediate feedback, and adjust the pace of the lesson if necessary.

EP8 presents the QuímicaMaster app, which offers pedagogical possibilities and can be used to recall definitions, consult the periodic table, balance reactions, and take quizzes. This application has some limitations, such as the fact that it can only be accessed through the Internet, but it offers several definitions of chemical concepts and activities that can help, for example, to review the content that the teacher has to work on. Regarding the learning process, EP8 states that "the application is not sufficient for the student to assimilate the content. However, in conjunction with classroom instruction, it can be a promising resource for content review". Therefore, the tool can provide explanatory materials on various chemistry topics such as atoms, molecules, chemical reactions, and chemical equilibrium, among others.

EP9 and EP10 introduced Wordwall, an online platform that allows you to create a variety of interactive activities such as quizzes, word games, puzzles and more to engage students in the learning process. It is a versatile tool that can be used in many ways in the

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classroom. EP9 points out that one of its pedagogical possibilities relates to "the use of ready-made game templates that can be applied with chemistry content". In this regard, EP10 considers that "the platform allows to create different personalized digital games with the content of the teacher's choice". Thus, it is understood that Wordwall is a powerful tool for teaching chemistry, allowing teachers to create interactive activities that help reinforce learning in a fun and engaging way. The various customization options make the platform suitable for everything from basic concepts to more advanced topics, facilitating the adaptation of content to the specific needs of students.

Wordwall offers a wide range of interactive resources that can make the learning process more engaging and fun, especially by exploring the visual resources made available by the platform, playfulness, whether worked in a group or individually and with the teacher as a mediator, can help understand the content (Nunes, 2021; Silva, 2021).

Socrative is a classroom assessment and interaction platform that allows educators to create interactive quizzes, activities, and exercises to engage students in the learning process. It is designed to encourage active student participation, assess student progress, and facilitate two-way communication in the classroom. Some of its pedagogical capabilities include interactive quizzes, formative assessment, polls and voting, interactive discussions, review sessions, immediate feedback, exam preparation, self-directed learning, active participation, group engagement, and comprehension assessment. These multiple pedagogical possibilities, according to EP11, "can help students identify and work through their difficulties by solving the proposed questions" when referring to some of the platform's features that involve quizzes, for example. EP12 mentions that some features make it possible to "monitor student assessment in real-time. Socrative is a versatile tool that encourages student interactivity and participation, making the learning process more dynamic.

EP13 and EP14 presented Quizizz, an online learning platform that allows educators to create interactive quizzes, games, and activities to engage students in the learning process, and this set of pedagogical resources allows teachers to assess student learning (Silva et al., 2022; Rodrigues; Nery Filho, 2016). It is designed to make learning more fun and engaging while providing opportunities for formative assessment and content review. Quizizz is an interactive tool that can be used for a variety of pedagogical purposes, from assessment to review and practice. Thus, EP14 believes that these pedagogical possibilities "can enhance the teaching process by making it more engaging, interactive, and effective, and by allowing students to

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learn at their own pace. It is important to align their use with learning objectives and choose pedagogically effective approaches to maximize their educational impact.

Kahoot is a game-based learning platform that allows educators to create interactive trivia, quizzes, and competitive games to engage students in the learning process. In addition, according to EP15, it also serves as a pedagogical way to "develop varied games that focus on the topic being worked on. It is designed to make the classroom more interactive and fun while promoting formative assessment and active student participation. Kahoot is widely used by educators as a tool to engage students and make learning more interactive (Junior, 2023). Therefore, EP15 and EP16 believe that the interaction between the teacher, the student, and the platform plays a fundamental role in the teaching and learning process, especially in educational environments that use technology and digital platforms such as Kahoot.

EP16 argues that Kahoot, among others, can promote active learning, understood as a pedagogical approach that places students at the center of the learning process and encourages their active participation, engagement, and responsibility for their own learning. In contrast to the traditional teaching model, in which the teacher usually plays a central role in the transmission of information, active learning emphasizes the active construction of knowledge by students (Brasil, 2018; Díaz, 2011; Vieira, 2012).

Active learning can be implemented in a variety of ways, depending on the context and teaching objectives. It can take place in the classroom, online, or in blended learning environments, with the main objective of enabling students to become autonomous learners, able to apply their knowledge effectively in different contexts. This pedagogical approach is widely recognized for promoting a deeper and more enduring understanding of concepts, as well as increasing student engagement and motivation to learn. Therefore, it is important to adapt strategies according to the characteristics of the students, the learning objectives and the content to be taught; the key is to actively involve students, creating an environment where they take an active role in their education, and this must be provided with or without the use of ICT.

5 CONSIDERATIONS

The integration of ICT in the teaching of chemistry is a fascinating and promising

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possibility to improve the pedagogical practices of chemistry students and, consequently, to promote more qualified training of future teachers in this field. Through undergraduate activities that explore different technological resources applied to the teaching of chemistry, it is possible to achieve several pedagogical benefits and advances.

First, the incorporation of DICT in the chemistry classroom enriches the learning environment, making it more dynamic, interactive, and accessible. This allows undergraduate chemistry students to experience the benefits and challenges of using modern technology in education, preparing them for future careers as teachers who master these tools. In addition, the DICT approach allows for greater personalization of instruction, meeting students' individual needs, and adapting to different learning styles. This is critical because students have different learning styles and can benefit from different approaches.

Therefore, this research leads us to look at different perspectives as future work, including the development of specific content for teaching chemistry that effectively integrates ICT. This includes the creation of software, applications, and interactive resources that are aligned with chemistry curricula. It is always valid to create several tools with multiple pedagogical potentialities, thus diversifying the range of possibilities for the chemistry teacher.

In view of the above, it is important to conduct longitudinal studies that assess the long-term impact of the use of DICT in the teaching of chemistry, both on the academic performance of students and on the effectiveness of future teachers who have been trained using these technologies. It is also important to conduct research that compares the effectiveness of Chemistry teaching with and without DICT, aiming to identify which tools are most effective in different educational contexts and with different student profiles.

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