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Teaching experiences on the use of learning and knowledge technologies (LKTs) for learning chemistry

Experiencias docentes sobre el uso de tecnologías del aprendizaje y conocimiento (TAC) para aprender química

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ABSTRACT

Schools in Latin America face the challenge of modifying their educational approach. The objective of the current research article is to analyze the teaching experiences in the use of learning and knowledge technologies (LKT) to learn chemistry in secondary schools in the municipality of San José de Cúcuta, Norte de Santander, Colombia. The study was based on a phenomenological methodology, with the participation of 03 teachers as key informants. The incorporation of CAT in chemistry teaching has increased the positive perception of students, creating an accessible and participatory learning environment. However, the non-academic use of devices requires specific pedagogical strategies, such as time management and structured activities that maintain the academic focus. Teacher training in digital competencies is essential to take advantage of ICTs.

Descriptors: school laboratories; digital skills; computer assisted instruction; chemistry education. (Source: UNESCO Thesaurus).

RESUMEN

Las escuelas en Latinoamérica se enfrentan al desafío de modificar su enfoque educativo. Para el actual artículo de investigación se plantea como objetivo analizar las experiencias docentes en el uso de tecnologías del aprendizaje y conocimiento (TAC) para aprender química en instituciones de educación media del municipio de San José de Cúcuta, Norte de Santander, Colombia. Se fundamentó desde una metodología fenomenológica, participando 03 docentes como informantes clave. La incorporación de las TAC en la enseñanza de química ha incrementado la percepción positiva de los estudiantes, creando un ambiente de aprendizaje accesible y participativo. No obstante, el uso no académico de dispositivos requiere estrategias pedagógicas específicas, como la gestión del tiempo y actividades estructuradas que mantengan el enfoque académico. La capacitación docente en competencias digitales es esencial para aprovechar las TAC.

Descriptores: laboratorio escolar; competencia digital; enseñanza asistida por ordenador; enseñanza de la química. (Fuente: Tesauro UNESCO).

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Research articles section

INTRODUCTION

Education as a bulwark of any society, from the training of its citizens contributes to different aspects of life that involve the social, economic, cultural, political and scientific spheres worldwide (García-Pazmiño et al. 2020). Education is essential to drive the progress and advancement of a nation, constituting the pillar of its education system. In this context, the skills and competences of teachers are elementary to achieve educational and pedagogical progress in the face of social challenges and complexities, especially the need to optimise technological knowledge (Lule-Uriarte et al. 2023).

Competences establish a set of skills that must be transmitted to students, facilitating their approach to knowledge through a progression model that ranges from the possibility of obtaining information that is combined with experience to reaching the ability to innovate (Trujillo-Flórez, 2022). This reinforces the idea that an integral and digitally competent education is fundamental for the development of social subjects with broad capacities to face the challenges of educational and scientific technological progress (Matamala, 2018; Valencia-Martínez & Correa-de-Molina, 2018). However, schools in Latin America face the challenge of modifying their educational approach in order to achieve the corresponding responses to the enormous demands of a global society in constant transformation, which at the same time demands within the contemporary era to train new students with the support of digital technologies (Cabero-Almenara & Valencia-Ortiz, 2019). Emphasising that the digital era is characterised by continuous changes and advances in technology that are part of the lives of students born in the midst of a technologised education where ICT are part of the daily lives of students; this requires reinventing and transforming the traditional methodology, which is no longer aligned with today's society (Poveda-Pineda & Cifuentes-Medina, 2020).

In any case, it is necessary to take advantage of emerging technologies to optimise educational processes and thus strengthen students' scientific competences, which are decisive in their education. In this regard, moving towards digitalisation in pedagogical processes leads to the optimisation of educational processes, teaching strategies, teaching, learning methods and an increase in assessment scores (Márquez, 2017). In view of this, the Colombian Ministry of National Education (MEN) highlights the relevance of ensuring lifelong learning in human beings that allows for the improvement of the skills they will need to perform adequately in the social sphere and achieve success in the workplace (Hincapié-Parejo & Clemenza-de-Araujo, 2022).

In Colombia, in the stages that define the different grades in both primary and secondary education, a teaching process is promoted that provides access to scientific, digital, artistic and humanistic knowledge, integrating social interactions and the natural environment. The main purpose is to prepare students for higher educational levels and their integration into society and the world of work, it is necessary to promote the advancement and strengthening of skills (communication, logical and analytical thinking), to understand and provide solutions to the problems that are part of everyday life and the challenges that the student must face and solve where they intervene (education, science and technology) (Arévalo-Duarte et al. 2016; Gallego-Henao, 2018).

In this scenario, the Colombian state has made adjustments from the educational authorities in order to achieve in society an education that is consistent with the challenges arising from the global reality and local complexities. Within this configuration, the social pedagogical strategy promoted by the Ministry of ICT through guidelines, public policies and key programmes over time, including "Computadores para Educar", "Plan Nacional", "@prende", "One Laptop Per Child", "Red Nacional de Computadores en las Escuelas", "Red de Maestros Digitales", "Educar para el Futuro", has become an intense necessity.

In this perspective, teaching techniques and methodologies in the use of new ICT trends have become an innovative environment that makes it possible to overcome obstacles in education, but can also generate new disparities in the same field, being essential to identify the different knowledge that students have before the possibility of an educational training from the virtuality

(Grijalba-Bolaños, 2020; Montero-Mahecha, 2021). In other words, teachers need to be trained and at the same time updated in order to be able to advance at the pace demanded by their students, which represents an incursion into new and novel environments (Martínez-Argüello et al. 2018; Suárez-Navarro et al. 2021).

In this way, the different forms required to teach chemistry combine the theoretical with the experimental, which is directly related to the conceptual development addressed in the different spaces (classroom or laboratory), leading to the application of practical mechanisms in the search for significant collaborative learning (Del-Valle-Calderón & Jiménez-Alonzo, 2024). However, during the emergency caused by the pandemic situation (covid-19), the use of virtual simulators and remote laboratories became an innovative alternative to support practical activities in chemistry teaching during the pandemic. However, these tools presented certain limitations, particularly in terms of real-time interaction and equitable access for all students. It also underlines the need to strengthen digital competences in both teachers and students to facilitate effective adaptation to new educational modalities (Salinas & Pérez, 2023).

Colombian education assumes, through teachers in the different areas of knowledge, an enormous challenge in the face of technological progress and its implications in education that leads to an innovative dynamism that needs to be put into practice from teaching through the incorporation of digital tools that stimulate academic development (Delgado-Rodríguez, 2020). A transformative approach where a new educational paradigm is established that requires adjustments in programmes, activities, strategies, technological competences, infrastructure and equipment that facilitate the determining role of the teacher in the face of constant changes and the enormous needs of students to learn in a different way as the main actors in the process (Flores-Tuco & Rojas-Samper, 2024).

There, teachers of natural sciences, especially chemistry, must be guarantors of the implementation, integration and innovation of these practices in their pedagogical praxis, continually reflecting on their teaching actions and on the needs of the students of this century. It follows that in recent years ICT have been used in an incipient way in the educational and pedagogical work of education professionals without giving them the importance and value that these trends represent to promote new learning where the student can not only develop their skills, but also lead the way from mediation to enhance the construction of new knowledge.

This is how CATs have emerged, which, according to authors such as Reynoso-Holguín et al, (2020)(2020), characterise a concept of innovative educational nature that stems from technology and knowledge where one of the representations of ICT as an effective means within the educational training that favours both teachers and students, whose main purpose is focused on improving the quality and effectiveness of the learning process (p. 128). This represents the opportunity for change in the face of old traditional teaching schemes that need to be overcome by the innovation and change offered by ICT.

With regard to the latter, it can be considered that the evolution of ICT towards ICT can be translated into a simpler element from a transformation in the teacher's pedagogical approach, through feedback and motivation that accepts innovation as part of the necessary transformation of learning (González-Martínez, 2021). Within the educational scenario itself, ICTs emphasise orienting ICTs towards a more didactic and formative use that will strengthen the acquisition of knowledge and teaching. This implies focusing on academic training methods and techniques based on the incorporation and use of new digital technologies; it means appropriation and mastery of ICT beyond just technological skills to promote true knowledge acquisition (Poveda-Pineda & Cifuentes-Medina, 2020; Rojas-Carrasco et al. 2023).

It is evident that the teacher's pedagogical work shows weaknesses due to the scarce management and appropriation of ICT, since the use of traditional strategies prevails in which the student is required to memorise principles and theories instead of fostering a deep understanding of their application. This reality limits the advancement of the learning process that promotes experimentation and reasoning. Although experimentation is an attractive

strategy for students, many fail to contextualise it and feel motivated by the rigorous method of execution.

In addition, it is convenient to quote (Monroy-Carreño & Monroy-Carreño, 2018), who state that throughout the historical process, didactics with respect to the exact sciences has represented a continuous challenge for educators, considering that it is difficult for them to find effective strategies to arouse interest and motivation in students, which hinders student learning, specifically in physics and chemistry, which has been the subject of discussion, due to the fact that academic performance is traditionally deficient. Teaching science at school level is a complex process, as the definition of strategies requires special attention due to the rigorousness of the integrated knowledge, which hinders students' understanding of chemistry and results in a decrease in their school performance.

This situation also affects the orientation of skills in schoolchildren that can lead to the strengthening of scientific competences, as the distancing of teachers from ICT as an innovative teaching element in educational activity has a negative influence on the acquisition of knowledge and mastery of chemistry content. This shows a gap between instruction and learning processes, which impacts both the acquisition of new and innovative learning and academic performance in terms of the implications for scientific skills. This gap reflects a traditional teaching approach where students are considered passive recipients of information, limiting their participation and forcing them to memorise procedures. This methodology has a negative impact on the school population that is part of the new knowledge society, since these schoolchildren perceive science as something complicated and reject its application in practice. Likewise, in the classroom, it is shown how the subjective part of the student is scarcely taken into account, given that notable attention is paid to the development of content, learning styles are not appreciated, classes are planned for a homogeneous group, which is not the case because in reality the marked differences between one student and another are evident.

Based on the above, the aim of the current research article is to analyse teaching experiences in the use of learning and knowledge technologies (LKT) to learn chemistry in secondary schools in the municipality of San José de Cúcuta, Norte de Santander, Colombia.

METHOD

This article derives from a doctoral project in educational sciences at the Universidad Metropolitana de Educación Ciencia y Tecnología (UMECIT), Panama, entitled: Design of a didactic pedagogical model based on CAT as an innovative alternative for the teaching of chemistry in secondary education in the municipality of San José de Cúcuta, Norte de Santander, Colombia; addressing issues related to teaching experiences on the use of CAT by students.

Therefore, it was articulated and based on a phenomenological methodology, allowing us to understand the subjective experiences of the use of Learning and Knowledge Technologies (LKT) in chemistry classes, which allowed us to capture the essence of individual and collective experiences of how LKT transform the dynamics of teaching and learning, as well as the emotional, motivational and cognitive implications that arise from these interactions.

It should be noted that, in the extensive manuscript of the doctoral project, 12 teachers were used as key informants; however, for the current research article, 03 teachers (key informants) with experience in the use of CAT were selected, allowing an immersion in diverse but representative subjectivities, thus fulfilling the phenomenological objective of capturing the essence of the experiences. It should be noted that these actors were coded:

Key informant 1: DAQ10IE4

Key informant 2: DAQ11IE4

Key informant 3: DAQ12IE4

Phenomenological interviews were used as a data collection technique (Guerrero-Castañeda et al. 2017), these were semi-structured with open-ended questions that allowed teachers to reflect on their relationship with ICT, exploring not only their practical perception, but also their affective perception and the meaning they find in the use of these technologies in chemistry learning.

The information was coded and analysed using inductive coding, focusing on capturing the subjective meanings attributed to CTs. This analysis allowed us to identify patterns of meaning and phenomenological constructs around the use of CTs, emphasising categories such as positive perception, increased interest, challenges in the appropriate use of devices, and need for teacher training. Each category is interpreted as a reflection of how CATs impact subject disposition and academic self-efficacy.

RESULTS

In relation to the experiences of the teachers, the use of ICT in the learning of chemistry is presented from the interview carried out, describing ontological aspects in table 1, related to the use of ICT in the learning process of chemistry; as can be seen in the following:

Table 1. Teachers' experiences with the use of ICT in chemistry learning.

DAQ10IE4	DAQ11IE4	DAQ12IE4
1. How do your students perceive the use of ICT in chemistry class? Have they expressed any preferences for specific tools or resources? Students love using ICT when they are applied in the right way. In terms of tool preferences, the use of e-mails and institutional platforms to communicate, the institutional platform, the educational web pages, applications and the use of videos stand out. All of this makes students want to use ICT, making this favourable for them and this makes them change the way they see the subjects, making them more interesting and making them want to participate more and in some way their academic performance can be increased.	1. How do your students perceive the use of ICT in chemistry class? Have they expressed any preferences for specific tools or resources? The students perceive the use of ICT ICT in chemistry classes in a positive way. They value the variety in teaching methods, as it is not always limited to the blackboard and dictation or group work with guides. This diversity shows them that learning can be organised and approached in different ways, which they consider favourable. In terms of preferences, they expressed a desire to use technology in the classroom and to have access to digital tools. However, they also point out the need for more knowledge about the tools and resources available to maximise their effective use.	1. How do your students perceive the use of ICT in chemistry class? Have they expressed any preferences for specific tools or resources? There is a great willingness to work in class using technology, there is a great motivation and desire to learn to manipulate the applications as well as to carry out the proposed activities. They like to work with applications that are brought to them and watch videos on the subject, but they do not know other tools to address specific topics in my area.
2. Have you noticed any changes in your students' motivation, participation or performance since incorporating CT into your classes? By integrating CT in chemistry teaching, I have observed a noticeable increase in students' motivation. They are generally more enthusiastic and excited to participate in the different activities, which reflects a greater interest and commitment to learning the various topics.	2. Have you observed any changes in your students' motivation, participation or performance since incorporating CT into your classes? I have observed that by incorporating CT in chemistry classes, students are more attentive and willing to learn.	2. Have you observed any changes in your students' motivation, participation or performance since incorporating CT into your classes? Since incorporating CT, I have noticed an increase in the motivation and participation of my students. They are more interested in interactive activities and collaborate more in group projects. The use of digital tools has improved their understanding of complex concepts and facilitated more dynamic learning, which is reflected in better academic

3. What challenges have you faced in integrating CT in chemistry teaching? How have you managed to overcome them? The biggest challenge we have faced in integrating CT in chemistry education has been the misuse of the devices. Chemistry has been the misuse of devices. Especially mobile phones, by some students. To overcome this problem, I have implemented strategies such as establishing clear rules on the use of technology in class and using applications that allow more efficient control of how the devices are used. I have also promoted activities that require the active participation of all students, ensuring that they stay focused on educational tasks.	3. What challenges have you faced in integrating CT in chemistry teaching? How have you managed to overcome them? One of the main challenges is that when using mobile phones for educational activities, some students tend to use them more for playing than for learning. They prefer to access games and other entertainment platforms rather than consult digital guides or participate in planned activities. To overcome this obstacle, strategies such as motivating students and setting specific deadlines for homework submission have been implemented. By limiting the time available and emphasising the need to use time efficiently, students become more aware of the importance of using time productively. For example, when it comes to the use of mobile phones for different activities, sometimes young people have their mobile phones more than anything else to play than to learn, so when they have their screens and their mobile phones, instead of opening certain things they prefer to play games or other video game platforms and not the ones they are looking at or want to look at a digital guide or different activities that can be planned from the mobile screens. I have managed to overcome them by motivating them and giving them a deadline, a time to deliver the activities they have to develop so that they see that they don't have all the time, that time is limited and they want to make the most of it. Other categories, we continue in the section.	performance. 3. What challenges have you faced in integrating CT in chemistry teaching? How have you managed to overcome them? Mainly time, curricular objectives, evaluation processes, improvement plans and other pedagogical and institutional commitments that require academic spaces must be fulfilled, and sometimes we fall short of the time required to implement alternative strategies. Another challenge we face is the poor availability of technological tools in the institution and spaces in the institution, there is only the computer room, but most of the time it does not have internet, and there is also little availability for the use of other academic areas.
Other categories		
DAQ10IE4	DAQ11IE4	DAQ12IE4
CT teacher training: Have you received specific training or training on the use of CT in chemistry teaching? What kind of training would you like to receive? Yes, I have received specific training on ICT in chemistry teaching, as my master's degree addressed this topic. Moreover, I repeat, as a	1. CT teacher training: Have you received specific training or training on the use of CT in chemistry teaching? What kind of training would you like to receive? I have not currently received training in this area. I would like to be trained in the use of virtual laboratories, simulations and teaching platforms related to	1. CT teacher training: Have you received specific training or training on the use of CT in chemistry teaching? What kind of training would you like to receive? I did a specialisation; but I have not received training in the use of digital tools and educational platforms from the institution or the departmental secretariat. I would like to receive advanced training in

member of the University, I have the privilege of participating in different seminars, talks and meetings that help us to become more qualified every day.	compound chemical reactions, the periodic table and artificial intelligence applied to chemistry education. Observing how developed countries use these tools in their education motivates me to learn more about platforms and technologies that facilitate student learning.	interactive simulations and augmented reality techniques to create more immersive and effective learning experiences.
2. Barriers and facilitators: What factors facilitate or hinder the integration of ICT into your teaching practice? One of the main barriers to the integration of ICT in teaching practice is the lack of teacher preparation. In the use of these technologies. If a teacher does not know how to handle tools such as the Internet, computers, smartphones or interactive tablets, this can significantly hinder the effective implementation of ICT in the classroom. For students, the challenge lies in ensuring that they learn to use these technological tools properly. Despite these obstacles, ICT offers great advantages in facilitating learning by providing interactive and accessible resources that enrich the educational experience.	2. Barriers and facilitators: What factors facilitate or hinder the integration of ICT into your teaching practice? Let's say that it can be an obstacle that we do not always have access to resources, for example, a computer room, time is very limited, for example, one hour a week to be able to work with a course, with virtual simulations or with capsules, to have access to the computer room, it would be good if there were also virtual laboratories, for example, for chemistry, but we do not have them and we do not have the knowledge of how to use them. Institutional support is also required, for example, to have tablet laboratories with internet where different reactions, compounds, well, in short, simulations could be carried out. It would also be good if all classrooms were equipped with video beams or televisions, with greater access and ease of use of technology in order to be able to implement better teaching.	2. Barriers and facilitators: What factors facilitate or hinder the integration of ICT into your teaching practice? CT integration is facilitated by access to technological resources, institutional support and the availability of time to plan and learn new tools. However, it can be hindered by unequal access to devices, infrastructure limitations and the need for continuous training to keep up with technological innovations.
3. Assessment of learning: How do you use CT to assess your students' learning? What technology-based assessment tools or strategies have you implemented? To assess my students' learning, I use a variety of CT-based tools to facilitate and enrich the assessment process. I use platforms such as Google forms to create and administer questionnaires and surveys, and perhaps for interrogative assessments that allow for immediate results. In addition, I use Google Drive to share and assess assignments and projects and to encourage the creation of mind maps. Students make use of online tools available for this purpose. I also ask	3. Assessment of learning: How do you use CT to assess your students' learning? What technology-based assessment tools or strategies have you implemented? In assignments to be submitted and handed in, in mock assessment forms for tests to be seen, on some platforms, using for example Who Wants to be a Millionaire? as a form of assessment. In terms of technology-based assessment tools or strategies, well, the appropriate development of the capsules, but the students present it as such in the notebook, but they are based on the information they obtain on the computer based on the educational capsules. The forms that they	3. Assessment of learning: How do you use CT to assess your students' learning? What technology-based assessment tools or strategies have you implemented? To assess my students' learning, I use technological tools such as interactive quizzes and self-assessment platforms. I also implement digital projects where students can present their work in creative formats such as videos or presentations. These tools allow me to get instant feedback and adapt the lessons according to the students' needs.

them to send me their activities and documents via email or upload them to the learning platform. This allows for an organised and efficient management of their work. Such tools not only facilitate assessment, but also promote continuous interaction and feedback with students.	develop by answering tests that are done online and at the end there is an evaluation according to the number of questions they answered, are the evaluation tools that have been implemented.	

Note: Own elaboration based on key informant interviews.

With regard to table 1 described above, it is evident that a set of knowledge framed in the reality that is shown in the classroom is presented; in fact, it is presented that the key informant DAQ10IE4, 2024: which points out**:**

Students love using ICT when they are applied in the right way. In terms of tool preferences, the use of e-mails and institutional platforms to communicate stands out, they like the institutional platform, as well as the educational web pages, applications and the use of videos. All of this makes students want to use ICT, making this favourable for them and this makes them change the way they see the subjects, making them more interesting and making them want to participate more and in some way their academic performance can be increased.

In this sense, it can be seen that the key informants point to a communicative relationship framed in understanding the dynamics that surround the object of study; thus, curricular objectives, evaluation processes, improvement plans and other pedagogical and institutional commitments that require academic spaces must be fulfilled and that sometimes we are short on time to be able to implement alternative strategies. This converges in the new ways of teaching. In fact, key informant DAQ12IE4, 2024 points out:

Another challenge we face is the poor availability of technological tools in the institution and spaces in the institution, there is only the computer room, but most of the time it does not have internet, and there is also little availability for the use of other academic areas.

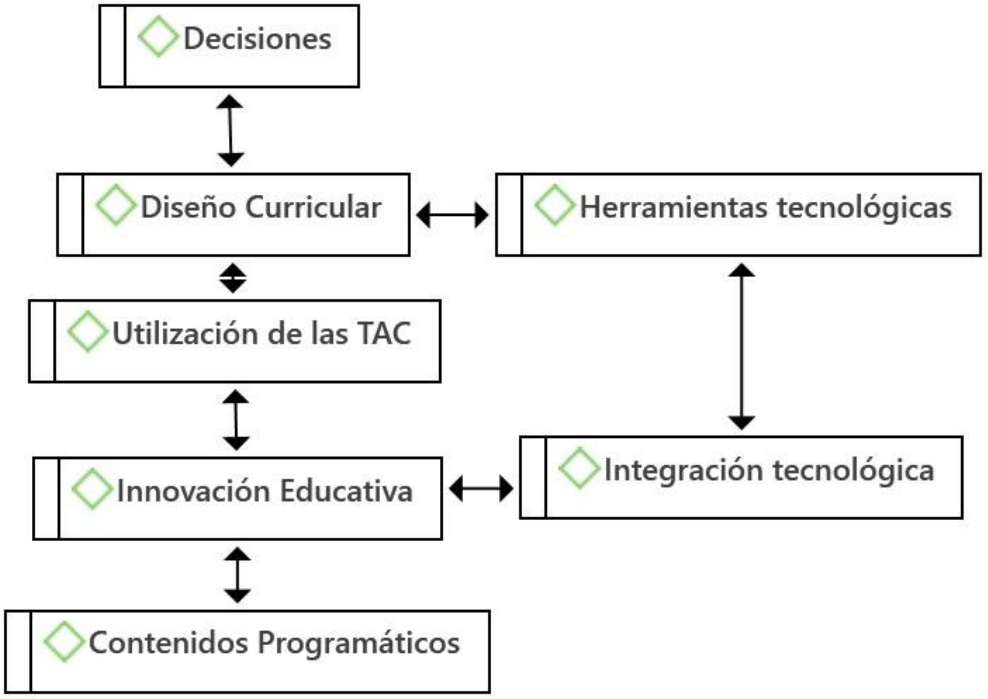

Figure 1**.** Students' experiences with the use of ICT in chemistry learning .
Note: Own elaboration.

Figure 1 shows what is the part of the technological tools and their integration to generate with it a link with the TAC; in fact it is possible to evidence that the TAC become a means to promote the teaching of chemistry according to what establishes the way for an effective teaching; reason that leaves the how the actions are allowed for teaching, in such sense it is appropriate to point out that according to what was found is that actions are going to be generated according to what is the part of the answers found; It is in this way that a closeness with the object of study is constituted; with the firm intention of establishing the bases of attention of the school population; bearing in mind that it is added to it what is the form and way of teaching in this case chemistry; which responds to the demands of a conventional class pattern. These aspects can be seen in the SANKEY diagram presented below:

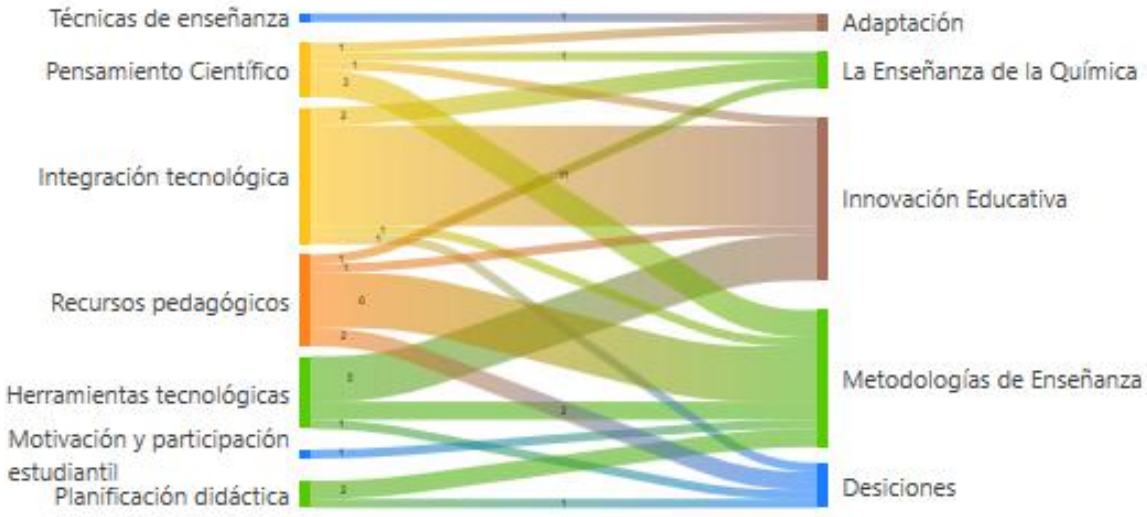

Figure 2**.** Response intentionality (SANKEY diagram) - 11 .
Note: Own elaboration.

According to the SANKEY diagram (Figure 2), it can be seen that the educational innovations respond to a deepening of the teaching of chemistry; this is how the actions that can respond with respect to teaching methodologies are constituted, as well as technological integration, which converges in a pedagogical teaching model and with didactic aspects that focus on scientific thought, on pedagogical resources and on some of the pedagogical resources. From this point of view, it is necessary to point out that a compendium of information is assumed that is framed in what is a pedagogical position that shows the reasons and therefore the components of the teaching of chemistry from what is the use of the TAC; this is how the bases of the model that is intended to be generated from the position of the use of technologies focused on the pedagogical innovations that are currently being experienced are constituted.

Student perceptions

In relation to the perception of the students it is necessary to point out that as it is an action research it is possible to see that a quantitative instrument was applied to thirty five students; with the intention of having a vision of what is the incidence of the TAC in the process of teaching and learning; this is how it is evidenced in a diagnosis (survey type instrument of multiple response selection); it is important to point out that the above mentioned is assumed with the intention of having an integral look of the research phenomenon; this is how the bases of the model that is intended to be implemented are constituted. Reason for which the most outstanding variables were taken; clarifying that mentioned information is assumed as a complementary source that allows to define by means of a descriptive statistical analysis that some elements are assumed that from the perspective of the students it is fundamental to corroborate what is to a great extent the contributions given by specialists on the topic that is being provided; it is a reality that is worth stopping to reflect with the intention of having very complete data on the object of study.

From this perspective, it is necessary to assume that the approach to procedural questions is related to what is an approach to questions of a procedural type; such is the case that the students were quite precise in their answers; it is thus that a set of actions, activities and elements which converge in this case in the teaching of chemistry are present; it is thus that some quantitative aspects of marked importance are seen; such that it is possible to evidence an accumulation of elements that allow, through quantitative data, to define what the impact of the application of the present research is. Based on what has been proposed so far, the students' perception can be summarised as follows:

Positive perception and increased motivation: Students find the incorporation of CAT in chemistry classes attractive, showing interest in institutional platforms, educational applications and videos that facilitate understanding and participation in complex topics. This preference reflects a change in the perception of the subject, making it more accessible and interesting, which improves their academic performance and willingness to learn collaboratively.

Challenges and solutions in device use: A common challenge is the misuse of mobile devices for non-educational activities. To counter this problem, teachers have implemented clear rules and structured activities that ensure a focus on academic tasks, keeping students focused on productive use of technology.

Teacher training needs: Continuous training in the use of CTs is essential. Teachers require competence in specific simulation tools and digital resources to maximise the educational potential of CT in complex chemistry subjects. This responds to an institutional need to provide adequate technological infrastructure and training to integrate up-to-date methodologies.

Assessment of learning through CT: Digital assessment tools, such as online quizzes and self-assessment platforms, have made it easier to monitor student progress. These tools allow for immediate feedback and help students to adopt an interactive and dynamic approach to their learning.

DISCUSSION

The impact of ICT in chemistry teaching highlights the potential of these technologies to transform traditional pedagogical methods and optimise learning. CTs facilitate an accessible and motivating environment, allowing students to explore complex content through interactive resources that foster self-management of knowledge (Arévalo-Duarte et al., 2016). This supports constructivist approaches, where learning is configured as an active and collaborative process, in contrast to passive models of teaching.

However, the use of devices presents specific pedagogical challenges. The tendency to use mobile devices for non-educational activities creates a disconnect in learning. To address this issue, pedagogical regulation and structuring of academic activities are essential, ensuring that the use of these resources promotes critical thinking skills and transversal skills (Poveda-Pineda & Cifuentes-Medina, 2020). In this regard, teacher training plays a vital role: if educators acquire digital competences, they can design learning environments that merge theoretical teaching with practical applications through simulations and virtual laboratories (Martínez-Argüello et al., 2018). This responds to an educational paradigm in which the teacher is no longer just a transmitter of knowledge, but a facilitator who guides meaningful and contextual learning processes.

In assessment, CT offers tools that allow for interactive formative assessment, thus responding to the diversity of learning styles and providing instant feedback. This model promotes metacognition, enabling students to reflect on their own learning process and adjust their strategies to improve their understanding of complex concepts in chemistry (Del-Valle-Calderón & Jiménez-Alonzo, 2024). The integration of CT tools redefines the role of assessment, making it an extension of the educational process and not only a final measurement, which is essential for a science education adapted to the challenges of the 21st century.

CONCLUSION

From the experiences provided by the three informants, it is highlighted that the incorporation of Learning and Knowledge Technologies (LKT) in chemistry teaching has increased the motivation and positive perception of students, creating an accessible and participatory learning environment. However, the non-academic use of devices requires specific pedagogical strategies, such as time management and structured activities that maintain academic attention. Therefore, teacher training in digital competences is essential to take advantage of ICT, while digital assessment tools allow for continuous feedback and promote adaptive learning. With the right institutional support, these technologies not only enrich conceptual understanding, but also develop scientific and digital competences needed in modern education.

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