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NEW DIGITAL TECHNOLOGIES IN THE TEACHING OF ORGANIC CHEMISTRY

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ABSTRACT

The present study investigated the use of new digital technologies in the teaching of Organic Chemistry, focusing on active methodologies that seek to overcome the traditional teaching model. The main objective was to understand how digital technologies can act as auxiliary tools in the teaching-learning process of this discipline. The research involved a literature review on the main technologies available and the pedagogical practices that incorporate them, as well as examining the impact on student engagement. The methodological approach consisted of a field research with questionnaires and interviews, applied to 30 teachers from the city of Linhares, ES. The results indicated that, although the technologies have great potential, their implementation faces challenges related to teacher training and student resistance. The research concludes that, for the effective adoption of these technologies, careful pedagogical planning and investments in continuing education for educators are necessary.

Keywords: Digital Technologies. Organic chemistry. Active Methodologies.

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Revista ARACÊ
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INTRODUCTION

The teaching of Organic Chemistry, traditionally focused on the transmission of abstract concepts through lectures, faces significant challenges in its practical application in the classroom (Chaves and Meotti, 2019). In this context, the introduction of new digital technologies and active methodologies appears as a possible solution to make teaching more dynamic and engaging for students. Technologies can not only facilitate the understanding of concepts, but also stimulate student engagement, promoting active and meaningful learning. According to Pinheiro et al. (2020), the lack of consistent implementation of these technologies in schools can be seen as one of the main barriers to improving the teaching of this subject.

The central problem of the research lies in the scarcity of application of new digital technologies in the teaching of Organic Chemistry. Resistance to the use of these tools and dependence on conventional methods are challenges faced by many educators. This scenario compromises the quality of student learning and limits the potential of technologies as facilitators of the educational process. Therefore, it is essential to understand how digital technologies can be used to transform pedagogical practices and contribute to more efficient and motivating teaching.

The general objective of this work was to understand the use of new digital technologies as an auxiliary tool in the teaching of Organic Chemistry. To achieve this goal, the following specific objectives were established: (i) to research the main technologies and digital resources available for the teaching of Chemistry; (ii) describe the benefits of new digital technologies in student engagement in class; and (iii) examine innovative pedagogical practices that incorporate digital technologies in the teaching of Organic Chemistry, beyond the conventional model.

With the increasing digitalization of society and the advancement of information technologies, schools need to adapt to integrate digital tools into their pedagogical practices. The incorporation of these technologies into the teaching of Organic Chemistry, an area full of complex content and abstractions, can represent a significant change in the way students relate to the discipline. However, the transition from traditional teaching to the use of technologies requires more than the simple adoption of new resources; it also requires a change in the pedagogical approach of teachers (Sonego and Baher, 2015).

Among the most mentioned technologies for the teaching of Chemistry are virtual simulators, educational software and learning applications, which allow the visualization of

Revista ARACÊ
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chemical phenomena that would otherwise be difficult to understand in an exclusively theoretical environment. Using these tools can provide students with a richer and more interactive experience, increasing their chances of retaining the content. However, the effectiveness of these resources depends on how they are used within the teaching context.

In addition, active methodologies, such as project-based learning, gamification, and the flipped classroom, have shown promise for teaching subjects such as Organic Chemistry. These approaches allow for greater interaction of students with the content, promoting the construction of knowledge in a collaborative and dynamic way. The combination of these methodologies with digital technologies can transform the classroom into a more stimulating and productive environment.

In this sense, the study of the relationship between digital technologies and active methodologies aims not only to understand how these tools can improve student performance, but also how they can transform the way teachers teach and students learn. The use of these technologies represents, therefore, a challenge and an opportunity for educators to rethink their practices and adopt new ways of teaching that are more aligned with the demands of contemporary society.

Throughout this article, the use of digital technologies in the teaching of Organic Chemistry will be discussed, based on the evidence raised by the field research, and the benefits observed in relation to student engagement and performance in class will be presented.

Finally, it is important to reflect on the implications of the integration of technologies in the teaching of Organic Chemistry. The transformation of pedagogical practices is not a simple process and requires a joint effort between schools, teachers, students and educational institutions. Adapting to the use of new technologies requires investments in training and infrastructure, as well as a cultural change that allows the use of these tools in an efficient and innovative way. Therefore, it seeks not only to explore the possibilities of using digital technologies in the teaching of Organic Chemistry, but also to contribute to a broader debate on the importance of pedagogical innovation in the current educational context.

Revista ARACÊ
ISSN: 2358-2472

THEORETICAL FRAMEWORK

The teaching of Organic Chemistry has faced challenges in the contemporary educational context, especially due to the memorization, complexity, and abstraction of the concepts involved (Pinheiro et al, 2020). The incorporation of new digital technologies has emerged as a promising alternative to transform the teaching-learning process, making it more dynamic, interactive and accessible. The integration of technological resources in pedagogical practices offers new opportunities for teaching this subject, overcoming the limitations of the traditional model and promoting more meaningful learning. Klier (2023) argues that the adoption of diversified methodologies is essential to create a more motivating learning environment, stimulating the development of students' critical thinking and facilitating the understanding of complex topics, such as Organic Chemistry.

Digital technology, when used effectively, can facilitate the understanding of abstract concepts and improve student performance. Alves et al. (2022) state that the incorporation of innovative technologies in teaching not only facilitates the understanding of content, but also increases student engagement, making learning more engaging and participatory. By integrating features such as simulations, animations, and augmented reality, educators can provide a richer experience, allowing students to explore three-dimensional models and glimpse chemical reactions in a more tangible way. Fagundes et al. (2021) point out that these technologies can make learning more intuitive, allowing for a clearer visualization of molecular structures and chemical processes.

Augmented reality (AR) and virtual reality (VR) have stood out as innovative tools in the teaching of Organic Chemistry. These technologies offer students the opportunity to explore content in an immersive way, which favors deeper learning. According to Ausubel (1968), learning is more effective when new content connects to students' pre-existing knowledge, creating a more robust cognitive structure. The use of AR and VR, by allowing students to see and interact with molecular models, facilitates this process of connection between the new and the already learned, promoting a more complete and lasting understanding.

In addition, gamification has proven to be an effective methodology in increasing student engagement. Cohen (2011) defines gamification as the use of typical game elements, such as challenges and rewards, to engage students in the learning process. This approach can be particularly useful in teaching subjects that, such as Organic Chemistry, can be seen as difficult and distant from the students' reality. Mendes (2012)

Revista ARACÊ
ISSN: 2358-2472

states that educational games increase the absorption of content, making learning more fun and less intimidating. Healthy competition and immediate feedback provided by games contribute to the reinforcement of learning, in addition to encouraging students to dedicate themselves more to the proposed activities.

Collaborative learning platforms also play a key role in student engagement. Lopes and Ribeiro (2018) highlight that these platforms allow students to work together, facilitating the exchange of ideas and collaborative problem solving. In the context of Organic Chemistry, where concepts can be challenging, teamwork favors students' understanding, as they can discuss issues and seek solutions together. The connectivity provided by these tools allows students, even if physically distant, to collaborate in real time, which strengthens collective learning and the development of social skills, essential for the integral formation of students.

Another innovative pedagogical practice that benefits from digital technology is the flipped classroom. Ferreira et al. (2020) explain that, by inverting the traditional dynamics of teaching, where content is studied outside the classroom and practical activities are carried out in class, students gain more autonomy in their learning process. This approach allows students to explore content at their own pace, using digital materials such as videos, podcasts, and interactive texts. Interaction in the classroom becomes more productive, with the teacher dedicating more time to solving doubts and carrying out practical activities, which favors more active and in-depth learning.

The use of virtual laboratories is another strategy that has been gaining strength in schools. Fagundes et al. (2021) argue that these simulated environments offer students the possibility of conducting experiments without the costs and risks involved in traditional laboratories. This approach broadens access to hands-on experiences, allowing students to experiment and repeat chemical processes over and over again, which would not be possible in a conventional laboratory. Thus, students have the opportunity to test hypotheses, observe results, and consolidate their learning more effectively.

Despite the evident benefits of digital technologies in the teaching of Organic Chemistry, their effective implementation depends on several factors, such as the training of teachers and the technological infrastructure of schools. For new technologies to really impact the quality of teaching, it is essential that educators appropriate these tools in a critical and reflective way, adapting them to the needs of students. This implies a continuous process of professional development, in which teachers not only learn to use

Revista ARACÊ
ISSN: 2358-2472

technologies, but also incorporate new pedagogical methodologies that favor more personalized and interactive learning.

The personalization of teaching is an aspect that deserves to be highlighted in the context of digital technologies. Moran (2015) points out that online learning platforms and educational applications allow content to be adapted to the individual needs and rhythms of students. This flexibility is crucial in the teaching of Organic Chemistry, since students have different levels of understanding about the concepts covered. Personalization favors more inclusive learning, in which each student can follow their own path, exploring the content autonomously and in their own time.

Digital technologies also have the power to promote more collaborative and interactive learning. Lopes and Ribeiro (2018) observe that digital communication facilitates group work and joint problem solving. In the teaching of Organic Chemistry, this is particularly important, because concepts often require analysis together, which enables the collective construction of knowledge. The use of platforms that encourage interaction among students contributes to the development of social and collaborative skills, essential for the formation of critical citizens prepared for the contemporary world.

In addition, gamification, as noted by Mendes (2012), offers an effective way to motivate students, making learning more attractive and challenging. The use of educational games can transform the teaching of Organic Chemistry, making it more dynamic and engaging. Prensky (2010) adds that games not only make learning more fun, but also encourage students to reflect on the content learned, which contributes to the retention of knowledge in a deeper way.

However, for digital technologies to be effective in engaging students, it is necessary for teachers to be trained to properly integrate them into the teaching process. As highlighted by Fagundes et al. (2021), the use of technologies is not enough on its own; It is necessary for educators to know how to use them in a pedagogical way, with a focus on active and collaborative learning of students. This requires an ongoing commitment to teacher training and the creation of educational environments that favor the effective use of these tools.

In summary, new digital technologies have great potential to transform the teaching of Organic Chemistry, providing more interactive, collaborative and personalized experiences. By integrating tools such as simulations, gamification, AR, VR, and online learning platforms, educators can create a more engaging and effective learning

Revista ARACÊ
ISSN: 2358-2472

environment. However, for these benefits to be fully realised, it is necessary to invest in teacher training and updating school infrastructure, ensuring that technologies are used critically and pedagogically.

METHODOLOGICAL PATH

In the methodological path, we will initially have the referral of the project for evaluation in the schools where the research and data collection will be carried out, the Regional Superintendence of Education must also be informed so that it is aware of the research. Then, the protocol will be submitted for consideration by the Ethics and Research Committee of Plataforma Brasil. This step is essential to ensure the necessary institutional support and obtain official authorization to carry out studies in the school environment.

As it is a quantitative research, the collection of professional and personal data is increasingly worrying, and it is essential to address the risks associated with the exposure of this information. The risks are: data leaks, violation of the privacy of participants, exposure of personal and professional data, and fear of judgment by co-workers.

To mitigate these possibilities of risks during the research, it is essential to ensure the anonymity of the participants and provide clear, simple and objective information throughout the process, the option of not wishing to participate in the research will also always be available to the members.

After obtaining institutional approval, teachers who agree to participate in the questionnaire will be duly informed about the objectives, procedures, and implications of the study. The inclusion criteria for the data collection include teachers aged between 30 and 55 years, who have accumulated more than 5 years of experience in the classroom. For the exclusion criteria, teachers who have less than 5 years of experience in the classroom will also be excluded from the selection, as well as teachers under 29 years of age or over 55 years of age, since the objective is to analyze the influence of new digital technologies in teaching with professionals who are in an intermediate age group, who have experience in teaching.

These 30 professionals will be invited to sign an Informed Consent Form, ensuring their understanding and voluntary consent to participate in the research. Then, the research protocol will be submitted to the Research Ethics Committee. This committee will review the project in compliance with applicable ethical standards and regulations,

Revista ARACÊ
ISSN: 2358-2472

ensuring that the research is conducted in an ethical and respectful manner, complying with all institutional requirements.

With approval from the Ethics and Research committee, this project will adopt an integrative literature review to identify the tools that have demonstrated the greatest potential to positively impact the teaching of organic chemistry and also effective pedagogical practices for high school students.

The present study will adopt a mixed-methods approach, combining qualitative and quantitative data to explore the use of digital technologies in student engagement. This work will be carried out in the city of Linhares, north of Espírito Santo. The city of Linhares has a population of 166,786 people, its Municipal Human Development Index (MHDI) is 0.724 and has 13 high schools, according to IBGE data (2021).

First, the quantitative approach of this research will involve the application of structured questionnaires to a sample of up to 30 teachers from the city of Linhares-ES, where these professionals work in two schools of the state education network, the schools are the "EEEFM José de Caldas Brito" and the "CEEFMTI Bartouvino Costa". The questionnaires will be applied to collect data on student engagement and the frequency of use of digital technologies in the classroom by teachers. The data of the professors who teach the discipline of chemistry will be analyzed with more emphasis and relevance for the research. After data collection, they will be tabulated and exposed in tables for the observation of patterns and data relevant to the objective of this research.

After data collection and proper tabulation, a qualitative approach will be conducted through non-participatory observational analysis of the practices of chemistry teachers from these two schools, specifically on the days when these professionals are in the classroom, developing and applying their chemistry teaching methodologies. The data collected will be interpreted, codified and analyzed together with the secondary objectives of this research. This approach will be essential to explore the perceptions, experiences and challenges faced by participants in integrating digital technologies into the classroom.

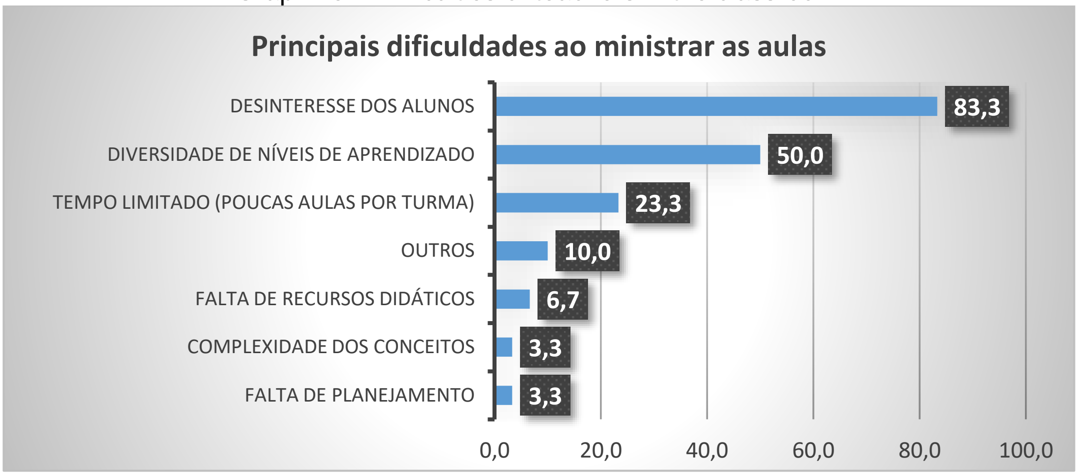
RESULTS AND DISCUSSIONS

The results of the survey indicate that teachers face significant difficulties in conducting their classes, with emphasis on the lack of interest of students (83.3%), which reflects a major barrier to engagement and effective learning in Organic Chemistry classes.

Revista ARACÊ
ISSN: 2358-2472

This lack of interest, combined with the diversity of students' learning levels (50%), limits traditional pedagogical strategies. This can be seen in graph 15 below.

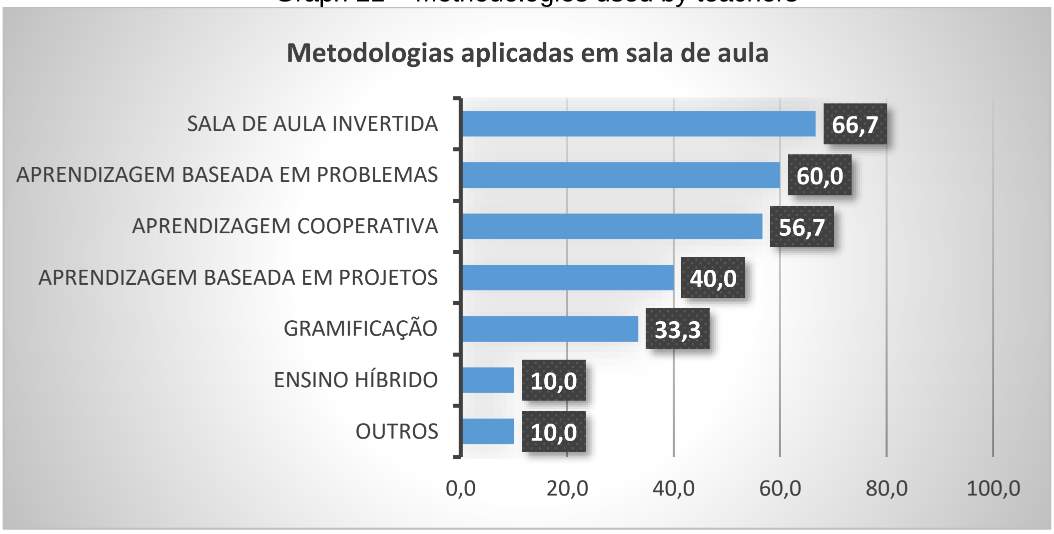
Graph 15 – Difficulties of teachers in the classroom



Source: Prepared by the authors.

In this regard, the search for alternative methodologies, such as active methodologies, emerges as an evident need to deal with these issues and explore more dynamic and engaging approaches (Behrens, 2012). The analysis of graph 21 reveals that active methodologies, such as the flipped classroom (66.7%) and problem-based learning (60%), have been progressively adopted by teachers, especially in order to overcome engagement challenges (Vieira et al., 2019). These methods were seen as efficient, with 60% of the teachers evaluating the impact of active methodologies as positive, as shown in graph 22.

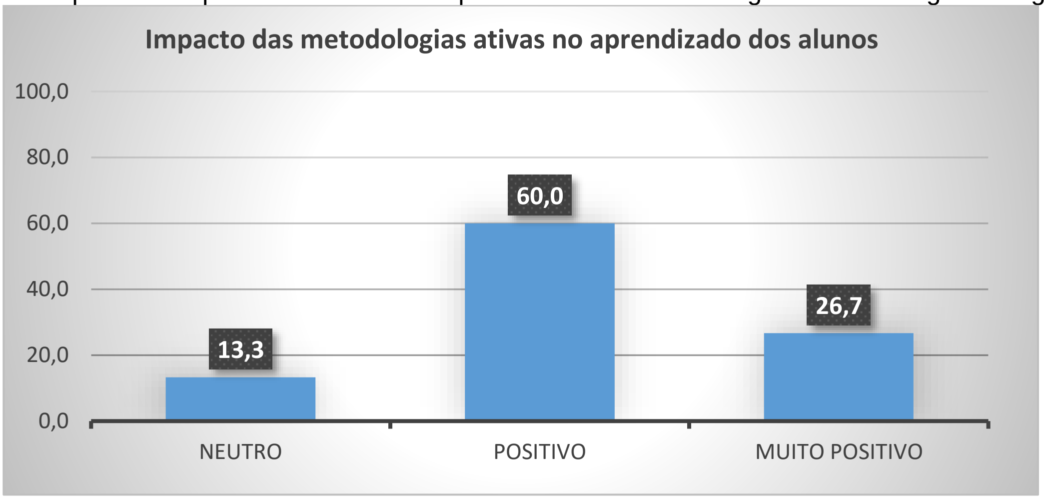
Graph 21 – Methodologies used by teachers



Source: Prepared by the authors.

Revista ARACÊ
ISSN: 2358-2472

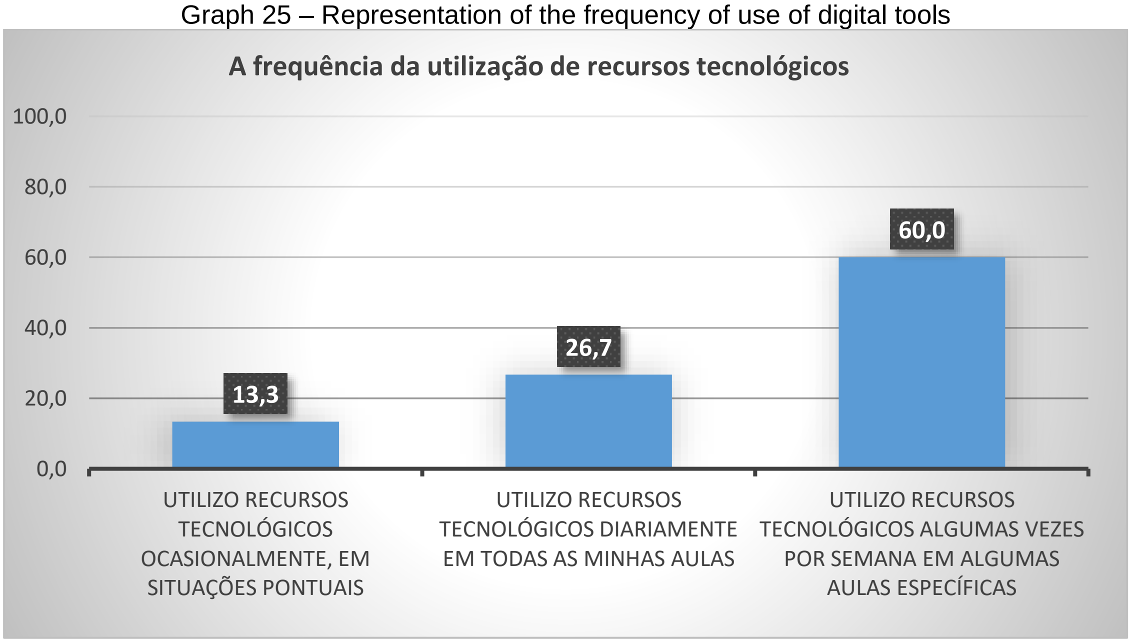
Graph 22 – Representation of the impact of active methodologies on teaching-learning



Source: Prepared by the authors.

Although the data point to a considerable use of technologies, as shown in graph 25, where 60% of teachers use digital resources a few times a week, the full adoption of technologies is still a challenge. This is reflected in the adequacy of the resources offered by the schools, with the majority of teachers (90%) considering the resources as partially adequate or totally adequate for the teaching of their subjects, as shown in graph 26. This indicates that, although schools provide basic technologies, such as the internet and notebooks, there is still a lack of a more robust infrastructure for the efficient use of more complex digital tools.

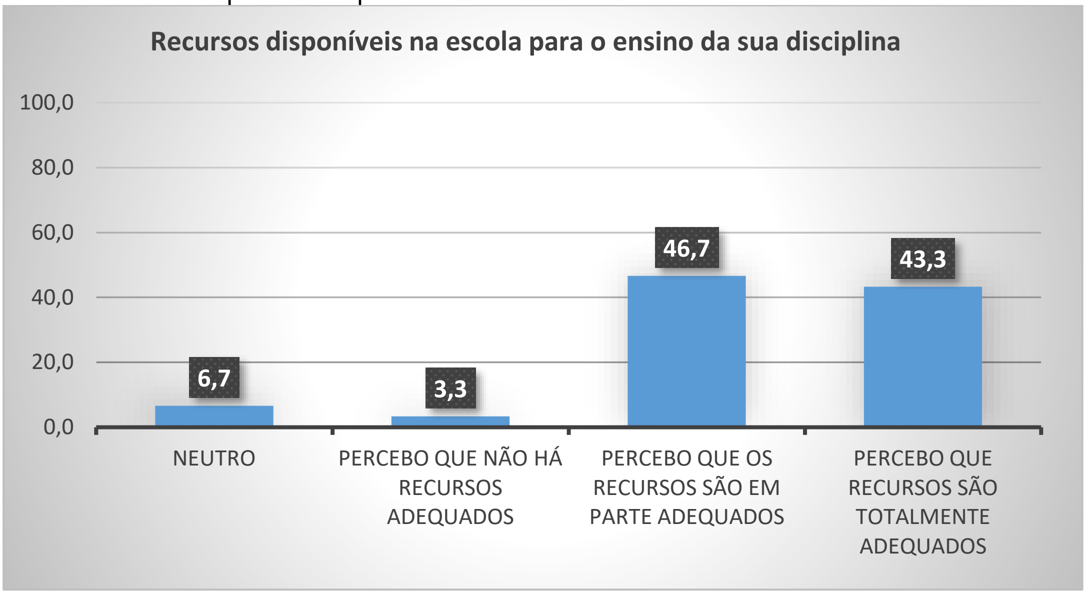
Graph 25 – Representation of the frequency of use of digital tools



Source: Prepared by the authors.

Revista ARACÊ
ISSN: 2358-2472

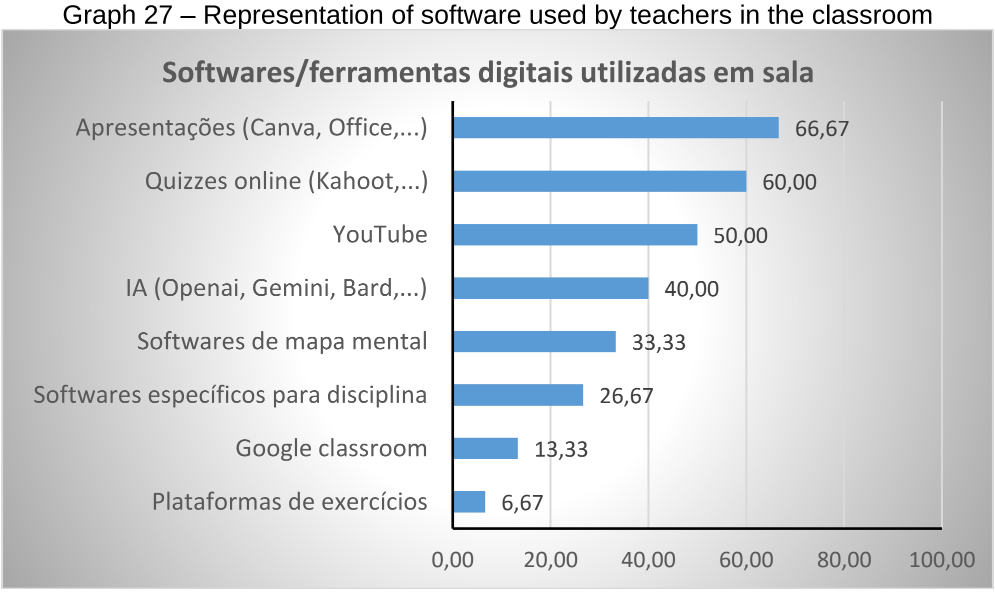
Graph 26 – Representation of resources available for classes



Source: Prepared by the authors.

The use of digital software was also a highlight Tools such as Canva, Kahoot and YouTube have been widely used to enrich the teaching-learning process, demonstrating that teachers are adapting to new digital tools (Lopes; Ribeiro, 2018). However, according to graph 28, the expectation regarding the use of digital technologies is clear: 73.3% of teachers expect them to improve student engagement, evidencing a need for greater dynamism in classes. This reflects a desire for more active and interactive learning (Bacich; Moran, 2018), one of the main objectives of the application of active methodologies in the teaching of Organic Chemistry.

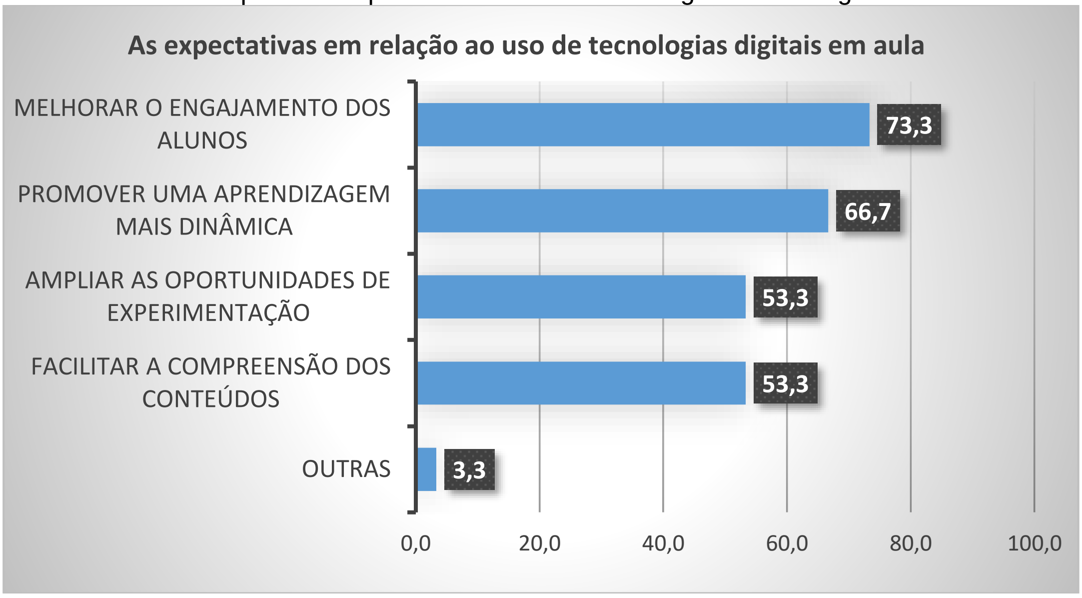
Graph 27 – Representation of software used by teachers in the classroom



Source: Prepared by the authors.

Revista ARACÊ
ISSN: 2358-2472

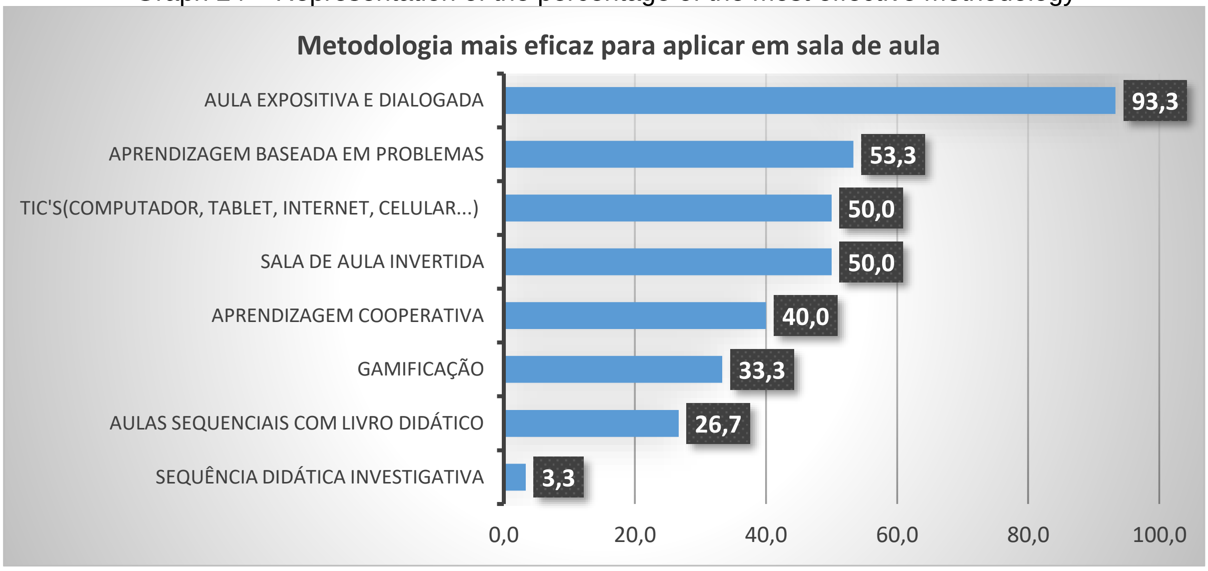
Graph 28 – Expectations for the use of digital technologies



Source: Prepared by the authors.

Regarding the effectiveness of the methodologies adopted, Graph 24 indicates that, for many teachers, the expository and dialogued class continues to be the most valued methodology, with 93.3% considering it effective. However, this positive assessment of traditional methodology is contrasted with the growing interest in more innovative approaches, such as problem-based learning and the use of technologies.

Graph 24 – Representation of the percentage of the most effective methodology



Source: Prepared by the authors.

This contrast suggests a gradual but steady transition in the teaching of Organic Chemistry, in which teachers increasingly seek to integrate pedagogical practices that

Revista ARACÊ
ISSN: 2358-2472

promote more engaging and effective learning, as observed in discussions about the use of active methodologies and digital resources.

CONCLUSION

The research concludes that new digital technologies, when incorporated in a planned way and aligned with active methodologies, have great potential to transform the teaching of Organic Chemistry. The data indicate that, despite the challenges faced, such as student resistance and the lack of specific teacher training, the use of these tools can improve student engagement and understanding. This study highlights the need for investments in continuing education for educators and the creation of more dynamic and interactive learning environments.

The research also suggests that for digital technologies to be effectively incorporated, it is critical that the school as a whole is committed to pedagogical innovation. In addition, the results point to the relevance of developing new teaching strategies that integrate digital tools and active methodologies more effectively.

While research has shown significant advances in the adoption of these technologies, the continuity and expansion of these practices depend on a cultural shift in schools and the education system as a whole. Encouraging the use of digital technologies should be seen as part of a broader transformation in science education.

In short, the research contributes to a greater understanding of the impact of digital technologies on the teaching of Organic Chemistry and paves the way for future investigations on the subject. The implementation of new methodologies should be seen not only as a necessity, but as an opportunity to revolutionize teaching and learning in science education.

Revista ARACÊ
ISSN: 2358-2472

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