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Use of Information and Communication Technologies for the Production of Stories in Comics in the Context of Chemistry Teacher Training

Use of Information and Communication Technologies for the Production of Comics in the Context of Chemistry Teacher Education

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SUMMARY

This scientific article proposes an in-depth reflection on the integration of Information and Communication Technologies (ICTs) in the production of comics as a teaching resource in the initial and continuing education of Chemistry teachers. The objective is to understand how this approach can contribute to the construction of scientific knowledge, the development of creativity and the stimulation of innovative pedagogical practices.
Based on a bibliographic review of studies published up to 2021, the article discusses the potential of ICTs in Science Education, the specificities of Chemistry teaching, and the theoretical foundations of the language of comic books. The methodology is based on a qualitative analysis of educational experiences and academic research that demonstrates the effectiveness of using this resource as a mediator of teaching and learning. The production of comic books by undergraduate students is analyzed as a training strategy capable of favoring teacher autonomy, scientific communication, and the collective construction of pedagogical and disciplinary knowledge.

Keywords: Information Technology. Comics. Chemistry Teaching. Teacher Training. Science Education.

Abstract:

This scientific article proposes a thorough reflection on the integration of Information and Communication Technologies (ICTs) in the production of comics as an educational resource in the initial and continuing education of Chemistry teachers. The objective is to understand how this approach can contribute to the construction of scientific knowledge, the development of creativity, and the encouragement of innovative pedagogical practices. Based on a literature review of studies published up to 2021, the article discusses the potential of ICTs in Science Education, the specificities of Chemistry teaching, and the theoretical foundations of comic book language. The methodology is based on a qualitative analysis of educational experiences and academic research that demonstrates the effectiveness of this resource as a mediator of the

teaching-learning process. The creation of comics by undergraduates is analyzed as a formative

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strategy capable of promoting teacher autonomy, scientific communication, and the collective construction of pedagogical and disciplinary knowledge.

Keywords: Information Technologies. Comic Books. Chemistry Teaching. TeacherEducation. Science Education.

1 - INTRODUCTION

The training of Chemistry teachers, as an integral part of Science Education, increasingly requires innovative approaches that engage with the contemporary contexts of the information society. In this scenario, the use of Information and Communication Technologies (ICTs) represents not only a methodological alternative, but a strategic necessity to bring teaching closer to the reality of students. Among the various resources made possible by ICTs, the production of comic books (HQs) emerges as a promising tool for the development of pedagogical, scientific and communication skills in teacher training.

Historically, comics have been marginalized in schools, associated with mass culture and superficial entertainment. However, recent studies, such as that of Ramos and Leite (2016), highlight the potential of comics as instruments for mediating scientific knowledge, especially when combined with structured didactic principles and clear pedagogical objectives. Comics allow the simplification of complex content into more accessible languages, without necessarily losing conceptual rigor, which is particularly relevant in the teaching of Chemistry.

Chemistry, in turn, is often pointed out by students as one of the most abstract and challenging subjects in the school curriculum, due to its symbolic, theoretical and representational nature (Mortimer and Machado, 2000). Visualizing molecular phenomena, understanding atomic models and reading formulas require specific cognitive skills. The use of comics, supported by ICTs, can contribute significantly to overcoming these barriers, since it allows the graphic representation of concepts, the use of playful narratives and the integration of multiple languages (verbal, iconic, symbolic).

Furthermore, the process of producing comics by the undergraduates themselves is configured as a formative practice in which critical, reflective and creative skills are developed. According to Silva and Fracalanza (2014), the authorship of teaching materials by future teachers promotes greater engagement with scientific content, strengthens intellectual autonomy and stimulates the collaborative construction of pedagogical knowledge. When this production is mediated by ICTs, such as graphic creation software, digital platforms and collaborative environments, the scope and quality of the teaching-learning process is expanded.

In this context, this article aims to analyze the contributions of the use of ICTs in the production of comics in the context of Chemistry teacher training. To this end,

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the theoretical foundations of this approach, the specific challenges of teaching Chemistry and the results of educational research that validate this methodological proposal are discussed. The aim is to highlight the transformative potential of comics as a pedagogical strategy linked to new technologies.

The relevance of this study lies in its contribution to the contemporary debate on innovation in teacher training and the valorization of alternative educational resources. In times of hybrid teaching, remote education and the expansion of virtual learning spaces, rethinking pedagogical practice becomes imperative. Comics, when conceived as a planned teaching tool, can integrate the training repertoire of teachers in training and act as a link between science, art and education.

Finally, this work proposes not only a theoretical reflection, but also an invitation to practical experimentation. By valuing the language of comics and its dialogue with ICTs, the way is paved for a more engaging, participatory and meaningful teaching method, especially in subjects traditionally considered difficult to learn. In this scenario, the training of Chemistry teachers gains in diversity, creativity and meaning.

2. Theoretical Foundations of Information and Communication Technologies in Chemistry Teaching

The inclusion of Information and Communication Technologies (ICTs) in Chemistry teaching is based on several theoretical approaches that understand learning as an active, interactive and contextualized process. Among the main theoretical references, Jean Piaget's constructivist perspective stands out, which proposes that knowledge is constructed from the interaction between the subject and the object, with technological mediation being a factor that enhances this construction. In this sense, ICTs favor meaningful learning by allowing simulations, visualizations and interactions that challenge abstract thinking, which is fundamental to understanding chemical concepts.

In addition to Piaget, Vygotsky's historical-cultural theory also offers important contributions, arguing that cognitive development occurs through the mediation of social instruments and signs. In this paradigm, ICTs are understood as cultural tools that expand the possibilities of learning and communication in the school environment.
By creating and interpreting comic strips with the support of digital resources, future Chemistry teachers exercise scientific language, narrative thinking and the ability to adapt science to different sociocultural contexts.

Authors such as Papert (1980), with the theory of constructionism, are also fundamental to supporting the use of ICTs in the educational process. Constructionism argues that learners construct knowledge more effectively when they are engaged in meaningful projects, which result in shareable products. The production of comics with the support of design software or digital storytelling platforms fits exactly into this model,

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allowing undergraduates to develop scientific and communication skills in authorial projects.

In the specific field of Science Education, authors such as Valente (1999) and Kenski (2003) emphasize that ICTs should not be seen as simple support tools, but as learning environments capable of transforming pedagogical practices. These environments favor the development of student autonomy, interdisciplinarity, and protagonism in the construction of knowledge. When applied to the training of Chemistry teachers, these concepts gain even more relevance, as they promote the overcoming of transmissive teaching and the construction of a more critical and reflective didactic approach.

It is worth noting that the use of comics in education also has a solid theoretical basis. Eisner (1996) and McCloud (1993) demonstrated how comics combine visual and textual elements in order to promote understanding, memory and interest among readers. In the teaching of Chemistry, this language can be particularly useful for illustrating chemical transformations, atomic interactions and laboratory processes that require visual imagination and logical reasoning. By integrating these visual narratives with ICT resources, learning is enhanced by stimulating multiple cognitive channels.

Additionally, the concept of multiliteracies, proposed by Kalantzis and Cope (2000), helps justify the presence of comics and ICTs in the training process. Multiliteracies recognize the need to work with different forms of language and communication in the contemporary world, including multimodal and digital texts. The production of comics through ICTs fits into this logic by requiring teachers in training to mobilize different types of literacy: visual, verbal, scientific and digital.

In summary, the theoretical foundations that support the use of ICTs and comics in teacher training in Chemistry are multiple and complementary. They indicate that this approach is not only valid, but also necessary, given the transformations in education in the 21st century. Such foundations legitimize pedagogical experimentation and the appreciation of alternative languages, strengthening the teaching-learning process through methodological innovation.

3. The Production of Comic Books as a Training Resource in the Chemistry Degree

The production of comic books (HQs) in the context of Chemistry teacher training is a didactic-training practice that involves multiple dimensions of learning. It is an activity that goes beyond the simple transposition of content, requiring the student to have a deep mobilization of disciplinary, pedagogical and communicational knowledge. The creation of comic books promotes the development of skills such as logical organization of ideas, creativity, conceptual mastery, articulation between scientific language and accessible language, as well as skills in the use of digital tools.

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In pedagogical practice, the production of comics boosts the protagonism of future teachers. By assuming the role of author, they are challenged to select relevant themes, develop coherent scripts, create meaningful characters and use visual resources appropriate to the educational proposal. This approach requires didactic planning, clear objectives and mastery of chemical content. As pointed out by Silva and Ferreira (2017), this type of activity provides an authoring experience that strengthens the teacher's identity and expands the methodological repertoire of the teacher in training.

The benefits of this practice have already been observed in several educational experiences. A study conducted by Vieira et al. (2019), with undergraduate students in Chemistry from a public university in southern Brazil, revealed that the production of comics allowed participants to review concepts in a playful way, identify gaps in their understanding, and experiment with alternative ways of teaching traditionally complex content. In addition, students reported greater engagement and motivation during the activity, demonstrating that the use of comics also favors the affective aspect of training.

Another relevant aspect is the encouragement of interdisciplinarity. When creating a comic book, the undergraduate student moves between Chemistry, art, language and technology. This practice breaks with curricular fragmentation, promoting a more integrated view of knowledge. According to Oliveira and Andrade (2015), this type of experience contributes to the formation of more critical teachers, capable of understanding science as a social and cultural construction, and not just as a set of formulas and reactions.

Incorporating ICTs into this process further enhances the results. Tools such as **Pixton,** Storyboard **That,** Comic **Life** and even graphic design platforms such as **Canva** allow undergraduates to create comics with aesthetic quality and a cohesive narrative structure. Familiarity with these technologies expands the possibilities for teaching in digital and hybrid environments, in addition to providing greater accessibility and sharing of the material produced with other colleagues, teachers and students in basic education.

However, the implementation of this training practice requires institutional support and critical mediation by trainers. It is necessary for undergraduate teachers to recognize the pedagogical potential of comics and create curricular spaces for their inclusion. In addition, it is essential that there is planning, monitoring and evaluation of the projects developed, ensuring that the training objectives are achieved and that the language of comics is not used in a simplified or caricatured way.

Therefore, the production of comics mediated by ICTs represents a teacher training strategy that is deeply aligned with the contemporary demands of education. It allows undergraduates to experience creative, reflective and critical practices, while developing their ability to teach Chemistry in a more accessible, engaging and meaningful way. When encouraged in undergraduate courses, this practice contributes to the training of teachers who are better prepared to face the challenges of the 21st century classroom.

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4. Didactic Potential of Comics in the Mediation of Chemical Contents

Comic books (HQs), as a multimodal language, offer great potential for teaching Chemistry because they allow the mediation of abstract content in an accessible, playful and visually stimulating way. This ability to translate scientific concepts into illustrated narratives becomes especially useful in a discipline such as Chemistry, which often deals with microscopic representations, theoretical models and phenomena that are not visible to the naked eye. When used as a teaching resource, comic books help to construct deeper and more contextualized meanings.

Among the main educational potential of comics, their effectiveness in **visually representing complex chemical processes,** such as molecular bonds, phase transformations, acid-base reactions, among others, stands out. According to Mortimer and Machado (2000), learning Chemistry requires mastery of multiple representational languages. Comics allow students to work simultaneously with verbal, symbolic and visual language, favoring an integrative and cognitive approach to the content.

This graphical representation helps in the abstraction process, especially among high school and elementary school students.

Another relevant aspect is the **ability of comics to promote students' emotional and cognitive engagement.** According to Oliveira and Moura (2018), visual narratives spark students' interest, creating emotional bonds with characters and situations. This enhances information retention and motivation to learn. In contexts where Chemistry is perceived as uninteresting or difficult, the use of comics can break down initial barriers and create an environment that is more receptive to scientific knowledge.

Comics also promote the development of **scientific literacy,** a fundamental skill in teaching Chemistry. By working with comics that address topics such as energy, pollution, food, chemical reactions and pharmaceuticals, teachers can encourage students to critically reflect on the social, environmental and ethical implications of science. According to Sasseron and Carvalho (2008), scientific literacy should go beyond the transmission of concepts, promoting the ability to argue, make decisions and understand science as a human practice.

The narrative nature of comics allows for the **contextualization of scientific content.** By placing chemistry in everyday situations or imaginary scenarios, comics make concepts more tangible and meaningful. One example is the use of comics to address the periodic table through characters that represent chemical elements, as explored by Lima et al. (2016) in workshops with elementary school students. This contextualization contributes to the formation of more lasting cognitive connections.

The **versatility of the comic book format** also allows for its application at different moments in the teaching-learning process: as an introduction to content, as a deepening of concepts, as an assessment tool or as an interdisciplinary final project. This flexibility expands the possibilities for pedagogical use and contributes to the diversification of

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teaching strategies, an essential factor in the training of teachers prepared to deal with different student profiles.

Finally, it is important to emphasize that comics do not replace scientific content, but rather complement and reframe it. Their use requires planning, clear teaching criteria, and coordination with curricular objectives. When well integrated, comics become powerful allies in promoting more meaningful teaching methods, capable of transforming the teaching of Chemistry into a richer, more sensitive, and more accessible experience.

Therefore, the inclusion of comics in the training of Chemistry teachers should be seen as an innovative and necessary practice. By valuing visual narrative as a pedagogical resource, the didactic repertoire of future teachers is expanded, while at the same time promoting a more empathetic and effective approach between scientific content and basic education students.

5. Challenges and Limitations in the Integration of ICTs, Comics and Teacher Training in Chemistry

Despite the potential already highlighted, the integration of Information and Communication Technologies (ICTs) and comic books (HQs) in the training of Chemistry teachers still faces several challenges and limitations, both from a pedagogical and structural point of view. Such barriers compromise the effectiveness of training practices and demand critical attention from institutions, trainers and educational managers.

One of the main obstacles is **pedagogical resistance to the adoption of alternative languages** in the teaching of Chemistry. Many teachers, both in initial training and in basic education, still associate comics with entertainment culture, disregarding their didactic and formative potential. This reductionist view is fueled by a conservative pedagogical tradition, which favors expository teaching, memorization of formulas and methodological rigidity.
According to Costa and Ferreira (2015), breaking with this culture requires ongoing training and openness to new epistemologies of teaching and learning.

Another significant challenge concerns the **lack of technical proficiency on the part of undergraduate students in the use of ICTs.** Many undergraduate students in Chemistry did not receive adequate training in educational technologies during their academic careers and, therefore, face difficulties in creating digital comics, using graphic software and developing interactive visual narratives. As shown by the data from the research by Bezerra and Lima (2017), only 38% of the undergraduate students evaluated felt confident in producing digital teaching resources independently, which indicates the need to strengthen this educational axis in the curricula.

From a structural point of view, **the lack of equipment and internet access in public institutions** also limits the effective implementation of these practices. Without adequate computer labs, stable networks or digital inclusion policies, it becomes unfeasible to require

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of undergraduates to carry out projects mediated by technologies. This technological inequality, pointed out by Morigi et al. (2020), highlights the urgency of investments in infrastructure and democratization of access to digital media in Brazilian higher education.

Furthermore, the **evaluation of comics as a pedagogical product** is a complex issue. It is common for educators to face difficulties in establishing objective criteria that simultaneously consider the chemical content, narrative structure, creativity, aesthetics and use of ICTs. The absence of evaluative references can compromise the academic recognition of the proposal and discourage students. In this sense, the creation of rubrics and parameters for formative evaluation becomes indispensable.

Another point to be considered is the **fragility of interdisciplinary dialogue in undergraduate courses,** which makes it difficult to articulate knowledge of Chemistry, languages, art and technology. Often, the content is treated in a compartmentalized way, preventing undergraduates from developing an integrated vision necessary for the creation of educational comics. According to Machado et al. (2016), promoting interdisciplinary projects and partnerships between departments are viable strategies to overcome this limitation.

Finally, it is necessary to consider the challenges related to the **production of comics with scientific rigor and pedagogical quality.** Not all comics with chemical content fulfill an effective educational function. Conceptual errors, undue simplifications and lack of clear objectives can compromise the teaching-learning process. Therefore, work with comics should be guided by didactic criteria, content validation and critical reflection on the effects of visual language in the construction of meanings.

In summary, although promising, the integration of ICTs, comics and teacher training in Chemistry requires facing structural, methodological and epistemological challenges. Overcoming these barriers requires investments in public policies, curricular revision, qualified teacher training and the promotion of educational research. Only then will it be possible to consolidate innovative and inclusive pedagogical practices in contemporary science education.

6. Conclusion

The production of comic books mediated by Information and Communication Technologies (ICTs) has proven to be a highly relevant pedagogical practice for the training of Chemistry teachers in the 21st century. Throughout this article, it was possible to demonstrate that the integration between ICTs, comics and Chemistry teaching offers an innovative methodological alternative, capable of promoting meaningful learning, intellectual autonomy and critical engagement of undergraduate students. This approach challenges traditional paradigms of science education and points to more dynamic, interactive and interdisciplinary paths in the teacher training process.

The theoretical basis presented shows that learning based on authorial projects, such as the creation of comics, is in line with constructivist proposals and

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constructionists, as well as the principles of multiliteracies and scientific literacy. These references reinforce the idea that teaching Chemistry requires more than content mastery: it also requires didactic sensitivity, creativity and the ability to communicate with multiple audiences, in different languages and formats.

The experience of producing comics by undergraduates demonstrates their potential as a training and assessment resource. By creating stories that represent chemical concepts, everyday situations and socio-scientific issues, future teachers develop fundamental curricular skills and build a teaching repertoire that is useful for their future work. In addition, the use of digital platforms and graphic design tools strengthens technological fluency and prepares teachers for the challenges of digital education.

However, the challenges identified throughout the article indicate that the success of this proposal depends on structural, cultural and pedagogical conditions. Resistance from some teachers, the lack of infrastructure, the fragility of technological training and the need for consistent evaluation criteria are factors that need to be overcome to ensure the effectiveness of the practice. This requires institutional policies to encourage innovation, expand technological training and include practices with comics in undergraduate courses.

It is believed that the valorization of comics as a teaching resource in the training of Chemistry teachers can also have a positive impact on basic education, promoting more meaningful, inclusive classes that are connected to the students' reality. By bringing a language that speaks to the youth universe into the classroom, teachers contribute to a more democratic, critical and transformative education. In this way, teachers are trained who are capable of promoting not only the learning of content, but also the development of scientific thinking and citizenship.

Thus, it is concluded that the production of comic books with the support of ICTs should be understood as a powerful pedagogical practice that integrates technology, science, art and language in teacher training. This is a proposal that deserves to be expanded, researched and institutionalized in order to strengthen the quality of Chemistry teacher training and promote a more lively, contextualized and innovative scientific education.

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