HOW TO MAKE THE VIRTUAL ENVIRONMENT INTERESTING DURING THE COVID-19 PANDEMIC?

COMO TORNAR O AMBIENTE VIRTUAL INTERESSANTE DURANTE A PANDEMIA DE COVID-19?

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ABSTRACT
Unexpectedly, social distancing became a rule, forcing schools and universities to introduce an emergency remote education. The information and communication technologies (ICTs) are being used in many cases only as a way of transmitting content, reducing its potential to promote interaction between users, contextualization to daily life, and failing to make the student a protagonist in their learning process. In this sense, knowing and handling the available tools is essential in the current moment of education. Thus, in order to perform a brief review and at the same time point out ways to research or use technological resources in teaching, this article reports, albeit modestly, some of the tools that can be used for teaching Chemistry at different levels and educational modalities of this science. For this task, several easily accessible resources were selected to bring ways of instigating and making remote classes more interesting in Chemistry learning.

Keywords: Remote teaching, Online experimental classes, Icts, Chemistry Teaching, College Education.

RESUMO
Inesperadamente, o distanciamento social tornou-se uma regra, forçando as escolas e universidades a introduzir uma educação remota de emergência. As tecnologias de informação e comunicação (TIC) estão a ser utilizadas em muitos casos apenas como forma de transmitir conteúdos, reduzindo o seu potencial para promover a interacção entre os utilizadores, a contextualização da vida quotidiana, e falhando em tornar o estudante num protagonista no seu processo de aprendizagem. Neste sentido, conhecer e lidar com as ferramentas disponíveis é essencial no momento actual da educação. Assim, a fim de efectuar uma breve revisão e ao mesmo tempo apontar formas de pesquisar ou utilizar recursos tecnológicos no ensino, este artigo relata, embora modestamente, algumas das ferramentas que podem ser utilizadas para o ensino da Química a diferentes níveis e modalidades de ensino desta ciência. Para esta tarefa, foram seleccionados vários recursos facilmente acessíveis para trazer formas de instigar e tornar as aulas remotas mais interessantes na aprendizagem da Química.

Palavras-chave: Ensino à distância, Aulas experimentais on-line, Icts, Ensino de Química, Educação Universitária.

1 INTRODUCTION

The mandatory social distancing due to the COVID-19 pandemic shook the traditional education system, based on 19th-century practices, whether in high school or university education. The adoption of Emergency Remote Learning (ERL) in the current scenario has led to the sudden use of technologies in the educational context. Some changes that would take decades were implemented in a few weeks (Rosa, 2020).

The abrupt way in which technology was implemented in education made ERL very far from the correct use of information and communication technologies (ICT). Generally, ICT was inserted instrumentally, reducing it to transmissive teaching such as

traditional education, and only as a replacement for the blackboard and textbooks (Moreira et al., 2020), keeping the teaching out of context, uninteresting, and not making the student the protagonist of their learning (Carmelo & Gomes, 2021; Godoi et al., 2020).

Considering a world in which students are inserted in the digital environment and find it easy to understand and apply it in different tools, the use of ICTs correctly favors the understanding of the contents taught, making the environment dynamic and contextualized for the student. For these reasons, it is necessary to discuss the use of ICTs dynamically in remote education (Neves & Santos, 2021).

The tools used need to be fully known and explored, since the simple transmission of content through them does not guarantee advances in learning or the quality of assessments. Therefore, the digital inclusion of teachers and students is essential for the success of any remote learning strategy (Moreira et al., 2020).

Approaches involving ICTs in the teaching-learning process must also be innovative and allow flexibility in teaching methods, as well as identify simple and widely available technologies to provide the formative role of teaching (Carneiro et al., 2020; "Nota Técnica: Ensino a Distância Na a Educação Básica Frente à Pandemia Da Covid-19," 2020).

Thus, to guarantee the quality of digital education, it is necessary to adapt, plan, discuss and evaluate strategies according to the context of each class, course, or subject, supporting the different types of interaction that are part of the teaching process, recognizing it as social and cognitive (Marques, 2020; Moreira et al., 2020).

However, teaching before the Covid-19 pandemic indicated the lack of preparation of teachers in the use of ICTs due to the low frequency of their use. This fact is confirmed in several studies that report the difficulty teachers have in including ICTs in the school context, at all levels of education (Carmelo & Gomes, 2021; Nabiça & Souza, 2021). Thus, it can be inferred that there are limitations in the online context, requiring teacher training. For example, organizing a distance learning course can take months of study and preparation, but the professionals involved with the ERL had only a few weeks to adapt their classes in a format that was not yet part of everyday classroom life (Hodges et al., 2020).

Thinking about the formation of the student at all educational levels, teaching must be guided to promote the student's autonomy and the development of the capacity for professional performance, not just the transmission of knowledge. Therefore, it is important that, both in higher education and in basic education, the quality of education

is a priority, even in times of pandemic, keeping the student as the protagonist of their learning process (Gusso et al., 2020).

Thence, this article suggests ICTs aimed at their use in teaching chemistry, both in high school and higher education, aiming to contribute to the quality of education in times of pandemic. It is noteworthy that for higher education in chemistry, only a few experience reports were found, without addressing strategies, guidelines, or suggestions to meet the demands generated (Rodrigues et al., 2021). Thus, the tools discussed here, help teachers who seek to diversify their activities and teaching methodologies, as well as present resources that can help in practical laboratory classes.

2 METHODOLOGY

A literature review was built focusing on the use of ICTs. To this end, a survey was carried out on scientific bases such as ISI-web of Science, Scielo, and CAPES Portal using the following keywords: remote teaching, online learning, digital education, ICTs, remote classes, teaching chemistry, education in the pandemic, COVID-19, and the equivalent expressions for these keywords in the Portuguese language. The choice of articles cited was due to the simplicity, accessibility, and contextualization of the resources addressed. Thus, a wide range of tools to aid the learning process was selected and can be used in teaching chemistry.

3 RESULTS AND DISCUSSION

3.1 DIGITAL EDUCATION PLATFORMS

Through the advent of the pandemic, several consolidated and well-known platforms started to offer products and resources aimed at schools and universities. The main platforms and resources that can be cited are Google, Google Classroom, Google Suite, Google Hangout, Google Meet, Facebook, Onenote from Microsoft, Microsoft, SEQTA, Perfect Education, Google Drive/Microsoft Teams, Moodle, Zoom, Seesaw, ManageBac, ManageBac, Ed Dojo EdModo, Mediawijs, Youtube, Whatsapp, Ebscohost, Progrentis, PhET, Screencastify, RAZ Kids and IXL. Moodle is one of the most used in academic courses (Carneiro et al., 2020).

Some of these platforms offer packages that can be purchased by educational institutions privately or by governments and made available to institutions, with features that change the purchase price.

3.2 APPS FOR MOBILE DEVICES

Known as mobile learning, learning through mobile devices (smartphones and tablets) makes the educational process more dynamic, expands the possibility of interaction, collaboration, and cooperation, and makes the environment more interesting. As well as enabling learning anywhere or at any time (Rodrigues et al., 2021).

When it is necessary to make concepts, models, and representations more visual, as in the structural representation of chemical formulas and molecules, programs and applications (Apps) are promising tools. The software used in computers still has a greater number of functions and tools, however, currently there are excellent adaptations for portable devices (Ferreira et al., 2019).

Some free smartphone Apps for the Android operating system available through the Play store that brings concepts, practices, videos, and questionnaires designed for teaching chemistry are:

- Hueckel Molecular Orbital HMO, Webmo, and Mobile Molecular Modeling - Mo3: This application brings the study of the theory of molecular orbitals of Hueckel, presenting the optimized 3D structure of the molecule and its orbitals and symmetry, diagrams of energy levels, binding order and charge formal, bonding atoms, valence, bond polarizability, allowing the calculation of eigenvalues, in addition to bringing properties taken from public databases. Also, the Hydrogen Atom Orbitals app allows you to specifically view hydrogen orbitals. All these apps facilitate the understanding of this microscopic concept about molecular orbitals.
- Organic Reactions, Organic Chemistry Flashcards, Reaction Flash; Organic Chemistry 4 Beginners, Mechanisms by Alchemie, Organic Chemistry, University Organic Chemistry Practice Questions: Cover organic chemistry concepts such as nomenclature, functional groups, addition, substitution, and elimination reactions, with detailed mechanisms of organic reactions, chirality, resonance, electronegativity, formal charge, and aromaticity.
- Engineering Thermodynamics, Thermodynamics, Thermodynamics and Thermodynamics (DMSApps): address the main concepts of thermodynamics, such as temperature and energy transfer by various processes, ideal and real gas law, the three laws of thermodynamics, Carnot's efficiency.
- Electrochemistry and SP Electrochemistry Corrosion: Contains books and references explaining the principle of corrosion and determining its rate, galvanic cells, pH diagrams versus illustrative potentials.

- Analytical Chemistry, Chem Wifi - Analytical Chemistry, Analytical Chemistry Lab Simulator, Analytical Chemistry Challenge, Chemistry Titration, Pharmaceutical Analysis, Analytical Chemistry: present basic calculations and statistics, chemical equilibria, electrochemical and spectroscopic methods, as well as classical methods of analytical chemistry. Separation methods, standard practices on compound preparation and standardization, instrument calibration, and reagent preparation, such as experiments containing UV-Vis spectroscopy, mainly contribute to this time of the pandemic, as well as contributing to institutions that do not have well-equipped laboratories.
- NMRss Free: allows the visualization of NMR spectra with changes in common deuterated solvents and Mobile Molecular Modeling (Mo3). Also allows the visualization of infrared spectra, NMR (nuclear magnetic resonance) of carbon and hydrogen, and mass spectra. The usefulness of this app is highlighted in higher education and postgraduate courses that use this analytical technique to provide detailed information about the structure, dynamics, reaction state, and chemical environment of molecules.
- Mastering Spectroscopy: This App can be used to interactively and dynamically practice the analysis of IR (infrared), NMR, and mass spectra for a huge number of organic samples. Identifying functional groups and types of protons on the charts and arriving at the compound based on the findings.

Another possibility when searching for more specific and personalized apps for a certain content would be the Application Factory, a useful tool that has free and paid functionalities, allowing users to create their own applications. It is also possible to use this tool as a means to assess students, leading them to create an application involving the content covered in the classroom. In the literature, several authors report the development of software for mobile phones, generally thinking about specific content. As an example, the software for cell phones, "Quiz Ambiental" developed by (Estevam et al., 2021), is an application that features a question and answer format, with multiple-choice questions of different difficulty levels.

3.3 COMPUTER SOFTWARES

In the previous topic, several smartphone applications were emphasized, as the mobile device is more accessible to all students. However, in the context of higher education, some software is useful and deserves to be mentioned. Some are available free of charge, requiring only a registration, such as ChemSketh, BKChem, and Avogadro

(Berton et al., 2020; Rodrigues et al., 2021). There are several paid softwares, however, they are less viable in the general context of Brazilian education, which has few resources in public institutions and in some private ones. Below, some works that report the use of software in teaching chemistry are presented.

Molecular modeling software, GuassView 5.0 and Gaussian 09W were used to promote a better understanding of concepts and calculations about the contents of Chemical Thermodynamics for undergraduate students in Chemistry and, according to the authors, after using these tools, students reported that the programs contribute to deepening thermodynamic knowledge, helping establish a more realistic and symbolic view of the microscopic world, minimizing mathematical limitations in obtaining calculations, and improving interest and motivation for learning (Sá et al., 2020).

Avogadro and Chemsketch software were evaluated in a case study involving students from the Chemistry Degree course in learning thermodynamic contents. After using the software, the authors realized that the proper use of the programs significantly contributed to the development of students' visuospatial skills, which are essential for learning abstract content, facilitating the understanding of thermodynamic content, involving aspects not normally discussed in the classroom, developing spatial visualization skills of compounds and helping to understand the micro and symbolic levels (Almeida et al., 2021).

3.4 WEBSITES AND WEB APPLICATIONS

The internet allows greater access for individuals to content and is not limited to the device on which it will be used, tablets, cell phones, notebooks. The volume of data is high, but disorganized, making it difficult for teachers and students to search, as well as to select them according to their quality. Some sites that provide free materials were selected and are mentioned below:

- e-Química: developed by Araraquara UNESP (Universidade Estadual Paulista) to address concepts related to graduation in chemistry, with videos, simulations, and animations.
- Quimidex: presents everyday chemistry using experimentation, developed by the Department of Chemistry at the Federal University of Santa Catarina (UFSC). It covers the themes of green chemistry and aromatic environments.
- Química Nova Interativa: website of the Brazilian Society of Chemistry (SBQ) that features articles from the journal Química Nova na Escola (QNEsc),

information on molecules, educational research, simulations, animations, and various useful materials for chemistry teachers and students.

- Só Química: a portal for chemistry content that brings elementary and secondary level content, trivia, history of chemistry topics, games, exercises, online simulations, and other information.
- Covalência, LabVirt, LDSE, and LEUTEQ: educational research pages.

3.5 BLOGS AND SOCIAL MEDIA

Blogs allow students to record their own activities and create their own spaces. They also provide a means for the sharing of ideas between students and teachers, enabling them to be used as evaluative activities as well as for other people who may be interested in the subject discussed. Some examples of blogs available are Blogs de Ciência and do Science Blogs, Clube da Química, Em Síntese, Ensino de Química, Ensino Virtual de Química, Histórias das Ciências (interdisciplinary), Pesquisas de Química, Química Ensinada, Química Periódica, Quimilokos e Simplesmente Química.

Although social networks are mainly used for entertainment, they also play the role of disseminating and diffusing information (Ferreira et al., 2019) and, like YouTube channels, several profiles focus on social networks as a way to disseminate content. For example, the posts link to the full content, present in blogs or websites. Instagram and Facebook are the most used networks and can be useful for teacher-student interactions, as well as for the dissemination of activities and content.

There are already studies showing the feasibility and efficiency of using Instagram in chemistry teaching (Vasconcelos & Silva, 2021) and in other areas, such as physics, languages, administration, arts, before the coronavirus. Among the various Instagram profiles that bring relevant chemistry content, the following stand out: @quimicanime; @quimicadivertida; @quimicadadepressaoreal; @bel.aquimica; @quimica.porque; @detonaquimica; @temquimicaaqui; @profselma.quimica; @doutorquimica. The great advantage of following profiles and using them as a resource in the classroom is that these profiles address chemical content in a playful, funny, and contextualized way, linking scientific knowledge and everyday life.

Whatsapp messenger is also a great tool to promote interaction, as well as Telegram, Twitter, and other social and communication networks. Ferreira et al. (2019) cite several chemistry-related blog pages (Química Periódica, Ensino de Química,

Quimilokos, and others) and social networks (Fala Química chanel, Cientista Didático, Quimicando, and others).

3.6 PODCAST AND AUDIOVISUAL RESOURCES

Teaching by different forms of stimulus contributes to effective learning, considering that each individual retains information depending on their predominant learning style. Among the approaches related to learning styles is the VARK model proposed by Fleming & Mills (1992). This is one of the best-known models and it is divided into four groups: visual, auditory, reading and writing, and kinesthetic. In this context, resources like podcasts and videos are relevant auxiliary tools in the learning process.

Podcasts are a way of disseminating content through radio broadcasts, and they have the potential to complement studies, as they can be listened to on smartphones while performing everyday tasks (Moreno & Heidelmann, 2017). Some examples are Molecules, Deviant, Periodic Table in Podcast.

Video resources have been used for a long time. Among the video tools, there is YouTube, which is a video-sharing platform, in which there are several channels that disseminate scientific knowledge. The great advantage of these channels is the power of choice they provide, where those who seek them can choose different teaching methods, class time, recording quality, and availability of support material.

This tool can help the chemistry teacher reinforce theoretical content as well as practical classes. But it is worth emphasizing the importance of looking for videos with reliable content, since, in the midst of the wide range of available videos, there are videos that often transmit wrong information. Thus, if the teacher thinks about asking students to search for content on YouTube, it should guide them in the search for reliable videos and instigate their critical sense in evaluating the chosen content.

This was the objective of a study, which sought to assess the choices of high school students in their search for video lessons on electrochemistry. For the authors, in terms of the teaching and learning relationship, the existence of materials of excellent quality was observed, as well as materials with no quality whatsoever. Given the results, the ability of students to choose a particular channel, in most cases, was linked to those with greater access and without specific criteria, which led students to attend classes that contained conceptual errors (Filha et al., 2021).

In this way, some channels were selected as examples of reliable content, such as the USP Channel, Química com Prof. Paulo Valim, Química do Sucesso, Química Simples, Café com química - Prof. Michel, The Best Professor- Profa. Simone Ávila, Prof. Diego Souza, Química Completa, Descomplica. These channels offer a range of videos, which are divided into content sequences, quick reviews focusing on entrance exams and ENEM, laboratory experiments, 3D views of structures, and other features.

In both approaches, podcast and YouTube videos, teachers and students can also develop their material, thus acting as a tool that promotes teaching and learning, in addition to acting as a means of evaluation, through the creation of videos and podcasts created by the students.

In the same context, several films, series, and music clips that relate to historical events linked to chemistry content or even tell the stories of scientists could be recommended. Another option would be to use video series of interest for students to explore facts in the episodes that chemistry could explain (Locatelli & Macuglia, 2018).

Some examples of films that have content related to chemistry are Perfume – The Story of an Assassin (distillation process), Radioactive (Marie and Pierre Curie) (radioactivity), The Nucleus – Mission to the Center of the Earth (radioactivity), Erin Brockovich - A Woman of Talent (environmental, water contamination by heavy metals), Sherlock Holmes (crimes unraveled through chemical concepts/knowledge), and Dirty Paradise (environmental, mercury contamination by gold mining). Some examples of video series are Chernobyl (nuclear plant), CSI (Crime Scene Investigation) (forensic chemistry), The Flash (atomic particles, radioactivity), and Dr. House (metal ions related to diseases). The interesting fact about the use of films and series is that they can be applied both in high school and higher education, to instigate students' learning.

A work recently published by (Castro et al., 2021) reports the use of TV series as support in radioactivity teaching in the Chemistry discipline in the senior year of high school at a state college. Initially, a brief presentation of the content was covered in slides, bringing the history of radioactivity and atomic models, also addressing the experiences of Wilhen Conrad Roentgen (1845-1923), the discovery of x-ray, the emission of radiation by the ore salt of uranium discovered by Antoine Henri Becquerel (1852-1908), the story of Marie Skłodowska Curie (1867-1934) and Pierre Curie (1859-1906). One of the series used was DC's Legends of Tomorrow. The results obtained showed that students exhibited interest and predisposition to learn significantly, assimilated the content in a non-arbitrary and non-literal way, giving it a new meaning in their cognitive

structure, and indicating the potential for significant learning (Castro, Assis, and Pimental, 2021).

Beyond movies and video series, it is also possible to use songs and their clips, available online quickly and easily, as an alternative to starting new content. Examples of lyrics and music videos are Radioactive (Imagine Dragons), Titanium (David Guetta and Sia), Iron Man (Black Sabbath), Oxygen (Jota Quest), which can be used to introduce content such as radioactivity, alloys of steel, metals, the importance of oxygen for terrestrial life and pollution.

3.7 GAMES

The use of games remotely arouses the interest of students, as well as in the classroom, and contributes to the acquisition of skills and competencies, such as collaboration, investigation, and problem-solving. For the game to be used as a didactic tool, it needs to contain or be related to some didactic content. The use of the didactic game must also be performed at the appropriate time so that it adds to the learning of the content (Cunha, 2012; Nabiça & Souza, 2021). Some examples of games are word searches, quizzes, match columns, and crossword puzzles.

Likewise that the Application Factory tool, there are other game creation platforms (free or paid) that can serve this purpose well. For example, the Educaplay platform, with creation possibilities: guessing games, dictations, interactive maps, word games, crosswords, and quizzes. Furthermore, the platform offers 1,898 games for the Chemistry area in different modalities.

Thereby, games can be useful to make Chemistry classes more dynamic, and the possibility of using educational games on devices contributes to learning and expands the classroom space to non-formal environments.

3.8 ONLINE LABORATORIES

As in other higher education courses with an experimental workload, experimental classes in the Chemistry course were directly affected and extremely harmful to the students' education. One way to alleviate this damage would be to watch a recorded experimental class or video. Another excellent option would be virtual laboratories, in which, even in a virtual way, the student can act as the protagonist and simulate the execution of experimental practices.

An example of this type of environment is Editora Pearson's Virtua Lab, which allows the execution of laboratory practices on the computer. Despite being a paid resource, the platform provides a test version for professors, as long as they request the program, through a registration, on the publisher's website.

Some open access options worth mentioning are USP's LabVirt and the University of Colorado Boulder's PhET project. PhET creates and delivers simulations in chemistry and other sciences. It allows working with several interactive simulations, the visualization of abstract concepts and microscopic aspects, as well as allowing the user to act in a variety of conditions of the system under study. In chemistry simulations, it is possible to work with concepts such as acidity and basicity, the polarity of molecules, balancing chemical equations, density, and even basic concepts of quantum chemistry, among others – all approached in a very intuitive and playful way.

4 CONCLUSION AND FUTURE PERSPECTIVES OF CHEMISTRY TEACHING

The Covid-19 pandemic accelerated the process of inserting ICTs in chemistry teaching, showed how they can contribute, especially at the present time, and how they can be versatile, being able to be used in different ways and contexts. Aiming to facilitate this process of implementation, this work, through a review and discussion on ICTs, indicated several strategies applicable in the classroom aiming at the construction of knowledge in the modalities of on-site and remote teaching, with the aim of helping teachers. Through the cited articles, it was possible to see how these tools can act as helpers in the construction of knowledge related to issues in a relaxed, dynamic, and contextualized way, and also act as a means of motivation, instigating, and making the student an active agent in the learning process. Many of the ICTs discussed are day-to-day tools for students and are therefore easy to access and apply.

As shown, there is a vast list of technological resources that can be used for teaching chemistry, and this list will increase given the constant technological evolution. For this reason, teachers must constantly update themselves in the face of new technologies and renew their teaching strategies and approaches.

Finally, it is expected that students and teachers have access to these tools and use them assertively in the classroom.

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