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APPLICATIONS AND THE TEACHING OF CHEMISTRY: EXPLORING NEW HORIZONS

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ABSTRACT

Chemistry, a discipline of Natural Sciences in High School, faces challenges related to the abstraction of its concepts and the perception of difficulty by students. In this context, the integration of Digital Information and Communication Technologies (DICT) can transform traditional teaching, promoting more dynamic and interactive approaches. The objective of the study is to develop a didactic material with a selection of applications for mobile devices, aligned with the National Common Curricular Base (BNCC), which facilitate the teaching of Chemistry and expand pedagogical strategies. The methodology included the elaboration of a descriptive table with educational applications, based on suggestions from Chemistry teachers and research on digital platforms such as Google Play and App Store. The applications were categorized considering their pedagogical objectives, functionalities, positive and negative points, as well as technical criteria such as language and compatibility. For easy access, the apps are presented with QR Codes that direct to download links and tutorials. The study classifies the apps into different categories: tutorials, practical exercises, simulators, educational games, and augmented and virtual reality tools. This diversity makes it possible to meet different pedagogical needs, making teaching more inclusive and adapted to students' learning styles. The use of these resources makes it possible to visualize abstract concepts, promoting the personalization of teaching, student engagement, and the development of skills such as critical thinking and problem solving. The final product aims to enrich the teaching of Chemistry and bring students closer to practical and contextualized learning.

Keywords: Educational Software. Chemistry. Middle school. Apprenticeship.

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INTRODUCTION

Chemistry is a discipline that is inserted in the Natural Sciences and their Technologies, one of the four areas of knowledge defined by the National Common Curricular Base (BNCC) in High School (Brasil, 2018). Because it presents concepts and formulas, sometimes abstract, it is often seen by students as a difficult discipline to understand, consequently, they often end up considering classes monotonous and tiring.

Thus, traditional teaching, often centered on the transmission of knowledge, has been flooded by the integration of technological resources that allow for more contemporary and interactive approaches. In the context of Chemistry, which is often surrounded by abstraction, the visualization of structures through digital applications can help the teaching and learning process, and has shown significant potential to facilitate the understanding of complex concepts.

However, it is up to the teacher to look for the applications that meet their objectives and insert them in their planning as a pedagogical contribution.

In this way, the integration of digital technologies in the teaching of Chemistry can arouse the interest of students and engage their learning more deeply. Using digital tools that allow simulations, molecular modeling, and virtual interactions allows students to visualize and understand phenomena that would otherwise be restricted to theoretical descriptions and formulas on paper. This approach fosters a more dynamic learning environment where students can experiment and explore concepts through hands-on, interactive activities.

In addition, the insertion of technological resources provides opportunities to personalize teaching, adapting content to the different needs and learning styles of students. This practice contributes not only to a better absorption of the content, but also to the development of skills such as critical thinking, problem-solving, and collaborative work, which are essential in the contemporary educational context. Thus, it is up to the educator not only to integrate these tools, but also to mediate the learning process so that students feel motivated and participative, creating an experience that goes beyond simple memorization and promotes a solid and applicable understanding of chemical concepts.

METHODOLOGY

In order to assist teachers in the adaptation and insertion of DICT in the school environment, a table was elaborated with the general characteristics of applications that can be used as pedagogical resources in Chemistry classes in different grades. This picture was developed as an educational product from the Master's Thesis entitled "Digital

Information and Communication Technologies: Perceptions of High School Chemistry Students", based on the suggestions of four Chemistry educators who work in a Basic Education School located in the municipality of Videira – SC. These indicated content to be addressed, taking into account the degree of complexity and abstraction of the themes, as well as criteria that facilitate the choice of applications. Thus, this product aims to offer teachers new perspectives for the use of mobile devices in education, in accordance with the syllabus provided for in the BNCC.

To arrive at the charts, we searched google play and app store, with the descriptors "applications" of "chemistry", applications that can be used as a pedagogical contribution in chemistry classes, considering the syllabus provided for in the BNCC.

To this end, they defined as relevant aspects to define in which category the application fits (Oliveira, 2001). In addition, it was identified for which operating system and language it is available. In the same way, it was sought to know the objectives of the software/application, its functionalities, positive and negative points presented by them. In the same way, we sought to know the objectives of the application, its functionalities, positive and negative points presented by them, supported by Ferreira (2021).

Finally, the product presents proposals for mobile applications generally available for free for Android and iOS digital platforms. The selected applications have great potential in enriching the theoretical content. However, it is up to the teacher to insert it within a planning with an inter/transdisciplinary approach and contextualizing the contents to be worked on.

The selected applications constitute the most varied categories: educational digital games, augmented reality, virtual reality, simulators, application for consultation, evaluation and new didactic tools.

Each application is presented to the reader by a board, where the main information about it is highlighted: name of the application, mobile platform on which it is available, language, if it works offline, objectives of the application, features, positive and negative points. In addition to the criteria highlighted above, access links to download the applications and a tutorial video to learn how to use them are presented in each frame. These access links are presented to readers in the form of QR Codes, two-dimensional codes that can be easily read by the cameras of modern smartphones. Thus, if the reader wants to access the content of the QR Code, just open the camera of your Smartphone and point to the text code, the reader's Smartphone will automatically make the suggestion to open the content of the code. If the QR Code does not open only using the Smartphone camera, it will be necessary to download a QR Code reader application on the Smartphone,

and only then be able to open the code. The use of QR Codes in this work is due to the ease of access to information when using them, the use of common links that are long electronic addresses of the type "www" offers an onerous job to the reader to fully type the link in the browser, discouraging the reader from accessing the information.

DEVELOPMENT

APPLICATIONS/SOFTWARE SELECTED ACCORDING TO THEIR CATEGORY

According to Tavares and Silva (2021), educational software can be classified according to its objectives into different categories, each with specific characteristics to meet pedagogical needs. Among the main types, tutorial software stands out, which is designed to teach content in a structured and sequential way, guiding users through clear instructions, explanatory examples, and practical activities that facilitate the assimilation of knowledge.

Another relevant type is exercise and practice software, whose purpose is to reinforce the learning already acquired through the repetition of exercises. This type of software is effective in consolidating knowledge, allowing users to fix content in a more consistent and lasting way.

Simulation software represents a particularly valuable category, as it allows users to interact with virtual representations of complex situations or systems. Examples of this include flight simulators and virtual labs, which offer a realistic and safe experimentation experience, promoting deeper understanding through the manipulation of variables and observation of results.

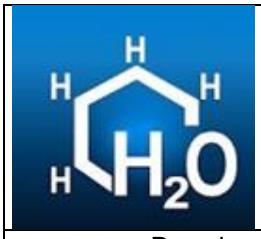
Finally, educational gaming software combines game mechanics with teaching objectives, creating an interactive and engaging learning environment. This type of software encourages user motivation by transforming learning into a playful activity, full of challenges that promote the development of skills and knowledge in a fun and stimulating way (Tavares and Silva, 2021).

TUTORIAL SOFTWARE-TYPE APPLICATIONS

Tutorial software represents an important tool in the educational environment, as it is designed to transmit new knowledge and guide the learning process in a structured and sequential way. The organization of these programs follows a pedagogical logic that seeks to facilitate understanding and assimilation by users, presenting content and activities in a gradual and progressive manner.

These software work as a kind of "teaching machine", where devices such as computers or tablets are used to provide detailed instructions, illustrative examples, and practical exercises. In this way, the user has the opportunity to learn autonomously and in a personalized way, advancing at their own pace and absorbing the content more effectively. This characteristic of individualization of learning is particularly valuable, as it respects the different speeds and styles of learning, making the educational process more inclusive and adapted to the needs of each student (Vieira, 2000 apud Martins, 2002).

Chart 1 - Application: Chemistry – Periodic® table

	Application Name	Chemistry – periodic® table
	Category	Software Tutorial.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		English and Portuguese
Objectives		Consult the periodic table and other tables related to the physical/chemical behavior of the elements.
Syllabus		• It presents a periodic table updated by IUPAC, containing 118 chemical elements. It contains the families, periods, groups differentiated by color, atomic symbols, element name, atomic number, and atomic mass. • When accessing a specific chemical element, the following are presented: its number of protons, neutrons and electrons, its electron configuration, the 118 animated representation of the atomic model of the element, its name in Latin, the year of discovery, oxidation state, electronegativity, ionization energy, melting point, boiling point, physical state in the CNTP and density. • Molar massa calculator. • Simulator of possible reactions and balancing for chemical substances. • Solubility table. • Table of electronegativity of the elements. • Table of molecular mass of organic substances. • Standard electrode potential table. •Acids strength table. •Table of the reactivity series of the elements.
Positives		The application is free of charge, works offline, presents a complete and updated periodic table with all the necessary information for its understanding. It goes further by offering other tools that complement its usability in various concepts covered in other Chemistry subjects, thus ensuring its use at various times in the student's school routine.

Negatives	Most of the tools are translated into Portuguese, but some features are exclusively in English.

Source: Grutzmacher (2024) based on Ferreira (2021)

APPLICATIONS SUCH AS SIMULATION SOFTWARE (AUGMENTED REALITY AND VIRTUAL REALITY)

Simulation software provides students with the opportunity to participate in activities and experiments that, under normal circumstances, might be unfeasible due to resource, safety, or accessibility constraints. Through these simulations, a virtual environment is created that mimics reality, allowing students to explore complex scenarios and systems in an interactive and engaging way. As Gamez (1998 apud Oliveira, 2001, p.55) points out, the "student can test and make decisions [...]", which encourages the development of critical thinking and problem-solving skills.

These tools enable students to manipulate variables and observe the results of their actions, providing experiential learning that goes beyond theory and promotes a deeper understanding of concepts. This approach not only expands the possibilities of experimentation, but also contributes to the development of practical skills and the assimilation of content in a more concrete and meaningful way.

Chart 2 – QuimicAR® Application

	Application Name	® Chemistry
	Category	Simulation (Augmented Reality).
	Availability	Android®
Download (Android®):		Download (iOS®):
Language		Spanish
Objectives		Address concepts of atomic structure and chemical reactions through augmented reality.
Syllabus		• Augmented reality application, composed of 5 markers with models of hydrogen and oxygen atoms and methane and oxygen gas molecules. • It aims to present the atomic structure of the elements mentioned and allows us to observe some reactions between them. • The virtual object is superimposed on the marker that must be printed (link below) by the teacher. When opening the application, the Smartphone's camera is used to insert the virtual

	element in the real context of the class. It is possible to visualize reactions such as combustion, bringing the markers closer to methane and oxygen gas or formation reaction, bringing the markers closer to hydrogen and oxygen.
Positives	The application is free of charge, works offline, has intuitive usability and is easy to understand. It uses augmented reality resources that contribute to the didactic deepening of the subject dealt with in a playful way.
Negatives	The language of the app is Spanish. There is no version available for the iOS platform (iPhone/iPad). It works only by the presence of the markers that have a limited number of models.
Link to print the markers:	

Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 3 – RAppChemistry Application: AR®

	Application Name	RAppChemistry: AR®
	Category	Simulation. (Augmented reality).
	Availability	Android®
Download (Android®):		Download (iOS®):
Language		Spanish
Objectives		To approach concepts of atomic structure of the 118 elements of the periodic table through representations using the Bohr model.
Syllabus		• Augmented reality app made up of 118 markers. Its objective is to present the atomic structure of chemical elements. • The virtual object is superimposed on the marker that must be printed (link below) by the teacher. When opening the app, the smartphone camera is used to insert the virtual element within the real context of the class.
Positives		The application is free of charge, works offline, has intuitive usability and is easy to understand. It uses augmented reality resources that contribute to the didactic

	deepening of the subject dealt with in a playful way. It provides the markers of all the current elements that make up the periodic table.
Negatives	The language of the app is Spanish. There is no version available for the iOS platform (iPhone/iPad).
Link to print the markers:	

Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 4 – BEAKER Application – Mix Chemicals®

	Application Name	BEAKER – Mix Chemicals®
	Category	Simulation.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		English
Objectives		Simulate chemical reactions with various simple and compound substances.
Syllabus		• Simulation application that converts the smartphone screen into a beaker where it is possible to simulate various reactions that could never be done in the school laboratory.
Positives		The application is free of charge, works offline (without internet access) and has intuitive usability.
Negatives		The language of the app is English.

Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 5 – Chemistry Lab® App

	Application Name	Chemistry Lab®
	Category	Simulation (Virtual Reality).
	Availability	Android®

Download (Android®):	Download (iOS®):
Language	Portuguese and English
Objectives	Simulate chemical reactions. It teaches us how complex basic processes become in chemistry, whether basic or advanced.
Syllabus	Virtual chemistry lab for everyone. It provides more than 300 chemicals and almost 1000 reactions. Feel free to do whatever you want.
Positives	It allows experiments to be carried out that would not be possible in schools.
Negatives	Paid app that presents a great degree of difficulty in understanding the contents. And there is a lack of items such as chemical elements and glassware.

Source: Grutzmacher (2024) based on Ferreira (2021)

Frame 6 – AR VR Molecules Editor Free® App

	Application Name	AR VR Molecules Editor Free®
	Category	Simulation (Virtual Reality).
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		English
Objectives		Address concepts related to atomic symbols, names of chemical elements, atomic number and atomic mass. It allows the construction of several molecules in three dimensions.
Syllabus		• Virtual reality application that allows the student to fully immerse himself in a virtual environment where it is possible to interact with a periodic table and all the information inherent to it, in addition to allowing the construction of several molecules in three dimensions.
Positives		The application is free of charge, works offline, has intuitive usability and is easy to understand. It allows the virtual immersion of the student in a playful learning environment.
Negatives		The language of the app is English. For the application to be fully operational, it is necessary to use augmented reality glasses or a cardboard viewer.

Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 7 – Plickers® Application

	Application Name	Plickers®
	Category	Simulation (Augmented Reality/ Evaluation)
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		English
Objectives		It allows the teacher to carry out a brief evaluation of the content in the classroom.
Syllabus		Assessment app based on augmented reality: in it, each student receives a unique printed marker in square format where each side represents an answer alternative (a, b, c, d). The teacher can generate various questions with options of four answer alternatives; students raise the marker with the answer side facing up, while the teacher quickly reads the markers through the application on their Smartphone. After scanning by the teacher, the application indicates how many students answered the question correctly, which ones got it wrong and which alternatives each one chose.
Positives		The application is free of charge, works offline (without internet access) and has intuitive usability. Only the teacher needs to make use of the application, the students use the paper markers. The app streamlines the classroom assessment process.
Negatives		The language of the app is English.

Source: Grutzmacher (2024) based on Ferreira (2021)

APPLICATIONS OF THE TYPE: EXERCISE AND PRACTICE SOFTWARE AND EDUCATIONAL GAMES

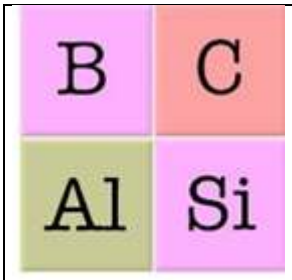
Educational games are a category of software aimed at teaching content and concepts through playful and interactive approaches (Martins, 2002). These programs are designed to make learning more enjoyable and dynamic by taking advantage of the intrinsic motivation generated by the challenges and rewards present in the game mechanics. Combining elements of fun and education, educational games stimulate students' interest, facilitating engagement and promoting more active and effective learning.

On the other hand, exercise and practice software have as their main focus the consolidation of previously acquired knowledge. They reinforce learning through the repetition of exercises, which helps to fix the content in a more solid and lasting way. This

approach is especially useful to ensure that the student understands and retains the fundamental concepts, preparing him for future applications in more complex contexts.

While educational games seek to integrate learning and fun, arousing curiosity and encouraging exploration, exercise and practice software have a more directive and structured character, focusing on reinforcement and constant practice to ensure proficiency in the contents. Both types of software play complementary roles in the teaching and learning process, offering features that cater to different pedagogical objectives and learning styles.

Chart 8 – Application Chemical elements and periodic table: test® names

	Application Name	Chemical elements and the periodic table: names test®
	Category	Educational Games. Exercise and practice or exercise.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		Portuguese
Objectives		Address concepts related to atomic symbols, names of chemical elements and atomic number.
Syllabus		Digital game in quiz format where the student must establish associations between names of chemical elements, their symbols and location in the periodic table. It is possible to explore information on the current 118 chemical elements in the periodic table.
Positives		The application is free of charge, works offline, is fully translated into Portuguese, has intuitive usability and is easy to understand.
Negatives		Unidentified.

Source: Grutzmacher (2024) based on Ferreira (2021)

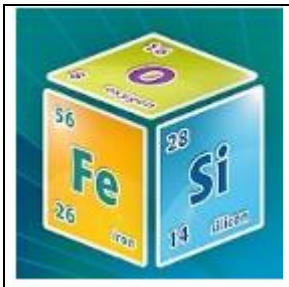
Chart 9 – Application The elements: flashcards®

	Application Name	The Elements: Flashcards®
	Category	Educational Games. Exercise and practice or exercise.
	Availability	iOS® (iPhone/iPad)

Download (Android®):	Download (iOS®):
Language	Portuguese
Objectives	Address concepts related to atomic symbols and names of chemical elements.
Syllabus	The application is a digital game of the flashcard type, small cards in which a scheme of questions and answers is created to help in the understanding of a certain subject. Because it is of the flashcard type, it is suitable to be played in pairs (two or four students), at which time one asks the other question and accumulates points.
Positives	The application is free of charge, works offline, is fully translated into Portuguese, has intuitive usability and is easy to understand. Allows more than one student to play at the same time collaboratively.
Negatives	There is no version available for the Android platform.

Source: Grutzmacher (2024) based on Ferreira (2021)

Table 10 – Quiz Application – Periodic Table®

	Application Name	Quiz – Periodic Table®
	Category	Educational Games. Exercise and practice or exercise.
	Availability	Android®
Download (Android®):		Download (iOS®):
Language		Portuguese
Objectives		Address concepts related to atomic symbols, names of chemical elements, atomic number, atomic mass, family, period and group.
Syllabus		Digital game in quiz format where the student must establish associations between names of chemical elements, their symbols and location in the periodic table. It is possible to explore information on the current 118 chemical elements in the periodic table.
Positives		The application is free of charge, works offline, is fully translated into Portuguese, has intuitive usability and is easy to understand.
Negatives		There is no version available for the iOS platform (iPhone/iPad).

Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 11 – Quiz Application – Chemical Symbols®

Cs	Application Name	Quiz – Chemical Symbols®
	Category	Educational Games. Exercise and practice or exercise.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		Portuguese
Objectives		Address concepts related to atomic symbols and names of chemical elements.
Syllabus		Digital game in quiz format where the student must associate atomic symbol with the name of the chemical element. It is possible to explore the symbology of the current 118 chemical elements in the periodic table.
Positives		The application is free of charge, works offline, is fully translated into Portuguese, occupies little device memory (13.7MB), has intuitive usability and is easy to understand.
Negatives		There is none.

Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 12 – Periodic® Table Quiz Application

Au Ouro g Prata	Application Name	Periodic Table Quiz®
	Category	Educational Games. Exercise and practice or exercise.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		Portuguese
Objectives		Address concepts related to atomic symbols, names of chemical elements, atomic number and atomic mass.
Syllabus		Digital game in quiz format where the student must associate atomic symbol to the name of the chemical element, name of the element to its atomic number, name of the element to its atomic

	mass, atomic number to the symbol of the chemical element. It is possible to explore information on the current 118 chemical elements in the periodic table.
Positives	The application is free of charge, works offline, is fully translated into Portuguese, takes up little device memory, has intuitive usability and is easy to understand.
Negatives	There is none.

Source: Grutzmacher (2024) based on Ferreira (2021)

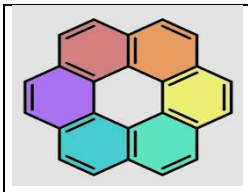
Chart 13 – Kahoot! ®

	Application Name	Kahoot! ®
	Category	Educational Games. Exercise and practice or exercise.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		Portuguese and English
Objectives		Support the teacher in the construction of quizzes on any subject of Chemistry, including topics related to the periodic table.
Syllabus		The app allows the teacher to build their own custom quiz, which can be a question and answer type and true or false. The quiz is saved in the teacher's account on the platform and can be reused whenever you want. Each student accesses the quiz from their own Smartphones through their account through a PIN code provided by the teacher. It is possible to request the student's participation from anywhere he is, or even ask everyone to participate during the same time, allowing the teacher to have real-time access to their performance report (hits and misses).
Positives		The basic features of the app are free of charge, intuitive and easy to understand. It allows the personalized construction of the questions by the teacher. They can be reused as many times as you want. It allows you to analyze in real time the assimilation of a given subject by the whole room or individually. There are ready-made quizze options on various subjects.
Negatives		It needs access to the internet, each student needs to access it from a different smartphone. Both teacher and student need to register on

	the platform to use it. Some resources are not translated into Portuguese.

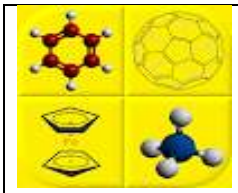
Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 14 – Hydrocarbons Application: the structures®.

	Application Name	Hydrocarbons: the structures®
	Category	Educational Games. Exercise and practice or exercise.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		English and Portuguese (Totaling 8 languages)
Objectives		Re-evaluate knowledge about hydrocarbons.
Syllabus		There are more than 180 structural formulas. The questions are divided into six topics. There are all the major hydrocarbons. Start with basic structures, such as CH4 methane, C6H6 benzene, and C3H8 propane. Then, you should move on to more advanced subjects. It has 183 structures and names of: alkanes; cycloalkanes; alkenes and alkynes; dienes and polyenes; aromatic hydrocarbons; polycyclic aromatic hydrocarbons.
Positives		The application works offline, presenting a list of activities on the different groups of hydrocarbons.
Negatives		The IOS® version is paid. And for Android, many are incompatible. It only presents the exercises without any previous content.

Source: Grutzmacher (2024) based on Ferreira (2021)

Chart 15 – Application Chemical substances – wanted

	Application Name	Chemicals – wanted
	Category	Educational Games. Exercise and practice or exercise.
	Availability	Android® and iOS® (iPhone/iPad)
Download (Android®):		Download (iOS®):
Language		English and Portuguese
Objectives		It allows you to learn more than 300 chemical substances that are studied in introductory and advanced chemistry classes.

Syllabus	Learn more than 300 chemicals that are studied in introductory and advanced chemistry classes. Compounds are divided into four major levels: 1. Inorganic chemistry: compounds of metals (such as LiH lithium hydride) and non-metals (carbon dioxide CO2); inorganic acids (e.g., sulfuric acid H2SO4), salts (including common salt - sodium chloride NaCl), and polyatomic ions. 2. Organic chemistry: Hydrocarbons (from methane to naphthalene) and carboxylic acids (from formic to benzoic acid). Natural products, including 20 amino acids and nucleic bases that are part of RNA and DNA molecules. You can also study the most important functional groups and classes of organic compounds. 3. All 118 chemical elements and the periodic table: the questions are divided into Periods one to seven. 4. Mixed compounds: * Systematic and trivial names. * Structures and formulas. * Organic, inorganic and organometallic compounds. * From acids and oxides to hydrocarbons and alcohols. * Two levels: 100 easy compounds and 100 hard compounds.
Positives	The application is free of charge, it works offline. It is presented in several languages.
Negatives	He does not have the resources to study (or review) the questions. It could show the mistakes after a quiz. And have an option to query the elements - you don't even need to add content, just enable query option.

Source: Grutzmacher (2024) based on Ferreira (2021)

FINAL CONSIDERATIONS

This material was developed to support teachers in the adaptation and insertion of DICT in High School Chemistry classes, modernizing teaching and making it more interactive and aligned with contemporary demands. The content includes detailed tables of educational applications selected for their functionality and pedagogical potential, facilitating the understanding of complex concepts and promoting student engagement.

Based on the need to expand the use of mobile devices in the classroom, this guide shows how, when well planned, these resources can transform the educational dynamic and provide more meaningful learning. In line with the BNCC, the material ensures that the suggested methodologies meet national guidelines.

The featured apps help you explore content in a visual and interactive way, especially abstract themes. However, its use should be part of a structured didactic planning, with an interdisciplinary approach, allowing for integrated learning. Teachers are encouraged to adapt the use according to the needs of their classes, ensuring that technology is a real ally and not just an additional tool.

It is hoped that this guide will inspire educators to incorporate DICT into their lessons, promoting more effective and relevant teaching through proper planning and tools.

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