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The use of informatics as a mediator and facilitator of the pedagogical process in the teaching of biology

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ABSTRACT
Educational practices in general have proven to be an interesting alternative in the teaching and learning process. Among these practices, the use of various dynamics and games stands out. However, despite the advancement of information technology in education, games and practices for biology teaching have had limited migration to this technological realm. To address this issue, this study aimed to survey mobile applications and electronic games focused on biology education. Additionally, several useful scientific software tools for biology studies were identified, encompassing areas such as molecular visualization, sequence alignment, database search for similarities, phylogenetic analysis, genetic sequence analysis, programming, and statistical analysis of biological data, visualization of biological networks, image processing, and protein stability analysis. A total of 14 mobile applications were selected, all available for the Android platform, along with 8 applications for iOS. Regarding electronic games, four games were found, including two in the form of Android applications and two for personal computers. These findings underscore the need to develop biology-focused games and applications, both collaborative and individual, to support elementary science and biology teachers, as well as the potential of using scientific software to enhance basic education.

Keywords: Applications, Games, Scientific Software, Pedagogical practices, Biology Teaching.

1 INTRODUCTION

The current society is inserted in a powerful communicational structure that, gradually, has surpassed the capacity with which we are accustomed to give answers to the messages of our daily lives (BENFICA, 2014).

For Silva (2011), "students no longer learn in the same way in the face of the attractions of digital culture". Schools seek, through technological mediations, to develop tools that assist in the teaching and learning process. Thus, it is perceived the existing efforts in education, to transform classrooms into motivating and meaningful environments for students.

Considering the context of the teaching and learning process, it is important to evaluate that it is a social experience, with the intermediary of instruments and signs. For the child this process is a spoken or written language, so knowledge is a social experience in which the relation of language is action. Oliveira (1997) states that "in its most elementary form the sign is an external mark, which

assists man in tasks that require memory or attention", complementing this idea Benfica (2014), states that it is necessary to involve actions that transform the teaching and learning process into an attractive and interesting model to the school environment.

2 PRACTICES IN THE TEACHING OF BIOLOGY

Vygotsky, during his observations, elaborated the so-called theory of intervention in the proximal zone of development (ZPD), where the child needs the relationship between the real and the playful, that is, one must consider not only the level of concrete development, but also its potential level. "This possibility of alteration in the performance of one person by the interference of another is fundamental in Vygotsky's theory" (OLIVEIRA, 1997, p 59).

Thinking in this sense and in line with the Law of Guidelines and Bases of National Education No. 9394/96, which emphasizes the importance of the student's contact with science and technology, providing him with knowledge pertinent to his daily life, the right of access to scientific knowledge is perceived, not being restricted only to systematized contents through pre-defined teaching programs. This decentralizes learning, making it an active rather than a passive process in teaching and learning.

Thus, although the student is considered an active being in the teaching-learning process, the changes related to teaching practices should normally be carried out by the teacher. By having a vision of the future and an open mind to reflect critically on their practice in the teaching-learning process, the teacher becomes an active agent in the educational system (TAJRA, 2012).

Examples of dynamics for teaching biology subjects, such as genetics and molecular biology, use simple materials available in schools. An example is the work of Moul (2017) entitled "Modelling in Genetics and Molecular Biology - Teaching Mitosis with Modeling Mass". Another example is the work of Pereira-Ferreira (2017), who mentions some activities carried out in the workshop of the VI National Meeting of Biology Teaching and VIII Regional Meeting of Biology Teaching (Regional 3), in Maringá (PR) in 2016. These activities can be seen in Chart 1.

Table 1 - Description of the materials used in the workshop "playing with genetics: Use of models and didactic games in learning"

Practice	Description
Representation: Genotype x Phenotype	Simple activity in which plastic cups are used to simulate chromosomes with adhesives to be used in the inscription of genes, which in the process of meiosis separate and later unite to form the genotype of an individual. Genes related to parts of a head are represented. The genotype resulting from fertilization and a guide frame of possible phenotypes serve as the basis for assembling the head of a generated individual, using plastic parts with Velcro.
Unwinding Chromosomes	It consists of letters with illustrations of specific karyotypes and related organisms/individuals. This activity can be used in several ways, and in the workshop in question, it was experienced as a memory game, to form pairs. The activity was carried out in groups, so that the participants had to turn a card from each group.
NEDICoid	It consists of a model in kits with several items: magnetized pieces that represent chromosomes to adhere to the metal plate and simulate meiosis, union of gametes. Several plasticized boards guide the understanding of the phenotypes that can be transferred, according to frames, to a three-dimensional biscuit model, representing the parts (antenna, tongue, type of food, paws, color, coating, etc.) of the hypothetical organism called NEDICóid. This model is more complex than the activity "Representation: Genotype x Phenotype" and addresses the different types of genetic inheritance.
Heredogram is a family thing	Activity in which participants assemble heredograms of widely known film families (The Lion King, The Flintstones, The Simpsons, Harry Potter) using pieces magnetized on a metal plate following tips.
Gene Flow Cord	Activity in which participants assemble a triple necklace using colored cords (3 colors), EVA pieces with specific colors and shapes that represent the nitrogenous bases (nucleotides) of DNA and RNA and codons simulating the processes through which information is transferred from DNA to proteins. Complementary forms associating the parts with the chemical structures, indicating correlations between the bases and the genetic code helped in the assembly process. The sequences to be represented were taken from real examples of known genes, contextualizing them.
Genetic tapon	The game consists of cards that form pairs and plastic hands with suction cups and rods to hold. In each pair, one card displays a drawing and another, a text that identifies it. The cards with drawings are on the table facing up and a mediator reads a text letter. Upon identifying the corresponding drawing displayed on the table, the player attempts to pick up the card using the plastic hand. In the end, the player who manages to pick up the most cards wins the game.

Source: adapted from Pereira-Ferreira (2017)

Another relevant work is the extension book Practices of Cellular and Molecular Biology for High School of Sepel (2017) published by the Federal University of Santa Maria (UFSM). Where the author makes use of the space to comment on good practices within the laboratory and proposes a simple technique of DNA extraction. Another interesting project is the Experimentoteca project (TOMAZELLO, 2000), a project carried out at USP that provides pedagogical practices for various

areas and teaching modalities. The examples of science practices aimed at Elementary School (EXPERIMENTOTECA, 2019) can be seen in Chart 2.

table 2 – Practical activities for elementary education proposed by the experimentoteca project for science discipline

Themes	Total practices
Air, water and soil	14
Living beings	10
Chemistry	6
Human body	8
Physics	10

Source: Authors

For high school, taking into account the topics related to biology, the portal (EXPERIMENTOTECA, 2019) as practices can be seen on the Board 3.

table 3 - Practical activities for high school proposed by the experimentoteca project for biology discipline

Theme	Goals
Plant Metabolism	- Identify the factors that contribute to the occurrence of the process of photosynthesis; - Observe the process of transpiration in plants and discuss its importance; - Observe how the transport of nutrients and other substances occurs in plants; - Discuss the relationship that exists between these three processes.
Evolution	- Understand how adaptations interfere with the survival and perpetuation of species.
Microscopy: animal and plant cell	- Observe the plant cell: its shape, chloroplasts, nucleus and stomata; - Observe the shape, size and nucleus of an animal cell and compare it with a plant cell; - Observe animal cells, fungi, bacteria, algae, protozoa, etc.
DNA	- Understand the structure of DNA and the processes of extraction, duplication and transcription.
Game: Synthesizing protein	- Understand how the process of protein synthesis occurs through a simulation; - Understand how proteins act on physiological processes; - To know the locations of the cells in which the processes of protein synthesis occur.
Gene expression and cell differentiation	- Understand the principles of gene expression and cell differentiation by analogy with origami.
Molecular biology	- Organize chronologically events and researchers of the history of Molecular Biology; - Relate this history to the stages of establishing a new science; - Check how the different areas of knowledge contribute to this process.
General Biology	- Bank of questions with the following themes: Biotechnology, Botany, Cytology, Ecology, Embryology, Evolution, Physiology, Genetics, Microbiology, Health, Zoology.
Games: Biomes	Game that simulates naturalists traveling continents in search of information.
Germination	-Compare the germination time of different seeds under the effect of different treatments; -Check the amount of germinated seeds under the effect of different treatments;

	- Compare natural situations of dormancy breakage of the seeds with the treatments performed.
Classification Systems	- Understand the importance of Linnaeus' classification system; - Identify organisms using a classification key.
Zoology	- To know the morphology and physiology of the different animal groups; - Compare the systems of the different classes of animals; - Understand how systems work; - Know the organs that make up the different systems.

Source: Authors

With this, it can be noted the importance of practice as part of the teaching process, since many initiatives have emerged over the years, making it fundamental for success in obtaining knowledge from the student, causing him to leave the comfort zone in a natural and spontaneous way.

2.1 GAMES AS PRACTICES FOR TEACHING BIOLOGY

The recreational activities over the years have gained more and more space, because these unite leisure to challenge (RIZZO, 1996). Of the various educational playful practices can be highlighted the use of games as a mediating tool in the teaching and learning process since games are a form of pastime and fun, even if they are subject to rules, acting simultaneously between more than one intelligence (ANTUNES, 2012).

Considering that games have this characteristic of stimulating multiple intelligences, it is possible to base it on the classification (Chart 4) of Gardner (1985) on the theory of multiple intelligences. This theory proposes that each student learns in different ways, and it is up to the teacher to evaluate and seek teaching and learning alternatives that help in the development of students' competencies. This challenge of the teacher, combined with the difficulty of teaching certain contents of biology, evidences the need for activities that enable effective learning (MORATORI, 2003).

Table 4 - Types of intelligence

Linguistic intelligence	Ease of use of oral and written language
Logical-mathematical intelligence	Interest in problems involving logical sequences and ordering
Spatial intelligence	Interest in puzzles (flat and solid figure shapes)
Intrapersonal and interpersonal intelligence	Ability to relate in the group
Musical intelligence	Mastery of sounds, pitches and tones
Kinesthetic body intelligence	Ability to assimilate large and small movements

Source: adapted from Gardner (1985)

In this sense, considering the games as an established form of playful activity, Passerino (1998) lists some indirect benefits provided by this practice, they are: memory, temporal and spatial orientation, visuomanual motor coordination, auditory perception, visual perception, logical-mathematical reasoning, linguistic expression and planning and organization. It can be highlighted that:

> [...] Games can be employed for a variety of purposes within the context of learning. One of the very important basic uses is the possibility of building self-confidence. Another is the increase in motivation (FERNANDES, 1995).

According to Krasilchik (2004), didactic games are simple forms of simulation, whose function is to help memorize facts and concepts, differentiating themselves from the pedagogical material by containing the playful aspect (CUNHA, 2012). Taking into account the above, Kishimoto (1996), treats the game as a means and not as an end of the didactic process. Considering the above aspects it is possible to evaluate that:

> [...] the use of models and the development of playful activities can help the teacher to arouse the interest of students in the subject of genetics, in which visualization becomes easier, so that students can interact with the material. The class becomes more enjoyable, motivating students to participate and get involved in the process. It is also important to use problem-questions, which lead students to seek solutions, building their knowledge with the mediation of the teacher (HERMANN, 2013).

In a survey of articles conducted by Hermann (2013) in the Journal of Genetics at School that dealt with didactic games in the teaching of genetics between the years 2006 and 2012, 29 articles were found categorized as follows: Board (7), Representative Models (13), Domino (3), Cards (2), Burnt (1), Virtual (1) and Memory (2), listed in Chart 5. And years after the survey conducted by Hermann (2023), we still see the development of physical dynamics, such as the case of the deck developed for teaching genetics by RODRIGUES (2020) in his master's thesis.

Table 5 - Games for teaching genetics

Article	Game type	Theme	Author
"Playing with cracks: to understand protein synthesis"	Board	Molecular genetics	SIQUEIRA (2010)
"Playing with the Blood System: alternative proposal for the teaching of ABO Blood Groups"	Representative Model	Classical genetics	BASTOS (2010)
"Classifying biological diversity"	TemplateRepresentative	Evolution	MORI (2013)
"Combine and recombine with dominoes"	Dominoes	Classical Genetics	KLAUTAU (2008)
"Meiotic track: the game of meiosis and chromosomal and allelic segregations"	Board	Classical Genetics	LORBIESKI (2010)
"Chromosomes, Gene and DNA: Use of a didactic model"	TemplateRepresentative	Classical Genetics	TEMP (2011)
"It contains Phenylalanine, can I eat it?"	Board	Molecular genetics	VALADARES (2010)
"Pin dynamics in the teaching of population genetics"	TemplateRepresentative	Evolution	KLAUTAU (2008)
"Domino of Structural Chromosomal Mutations"	Domino	Classical Genetics	FIELDS (2010)

"Genetics in Everyday Life: The ABO System in Blood Transfusion"	TemplateRepresentative	Classical Genetics	DASILIO (2009)
"Hypertension: A Multifactorial Genetic Inheritance."	TemplateRepresentative	Multifactorial Genetics al	PIZZOLATO et al., (2010)
"Memory Game: Where's the Gene?"	Memory	Classical Genetics	PAES and PARASQUE (2009)
"Burning Game: A Practice for the Teaching of Genetics"	Burn	Concepts of classical and molecular genetics	FREITAS et al., (2011)
"Galapagos Game: The Extinction and Irradiation of Species in the Construction of Biological Diversity"	Model Representative	Evolution	OLIVE (2008)
"Profile in Genetics"	Board	Classical Genetics	ARAUJO (2012)
"Helping to fix the concepts of genetics"	Dominoes and Cards	Concepts of Classical Genetics	RAMALHO (2006)
"Genetics revising and fixing concepts"	Model Representative	Concepts of classical and molecular genetics	JUSTIANINO (2006)
"Playful way of understanding genetic drift"	TemplateRepresentative	Evolution	SOUZA (2006)
"On the Trail of Blood: The Game of Blood Groups"	Board	Classical genetics	VALADARES (2009)
"The deck as a tool in the teaching of genetics"	Letters	Classical Genetics	SALIM (2007)
"Organization of an Olympiad of knowledge with the game evolving genetics"	Board	Concepts of Genetics	PAVAN (2006)
"Genetics Profile: A Fun Way to Memorize Content"	Board	Classical Genetics	Sant'ANNA et al. (2011)
"Burning your head! Understanding Fragile X Chromosome Syndrome"	TemplateRepresentative	Classical Genetics	BIRTH (2009)
"Genetics Show: An Interactive Game for High School"	Virtual	Molecular genetics	MARTINEZ (2008)
"Chromosomal syndromes without a new perspective on learning"	Memory	Classical Genetics	GOMES (2011)
"Blood system without mystery: an alternative proposal"	TemplateRepresentative	Classical Genetics	FIELDS (2009)
"An interactive way to teach genetics in elementary school based on the rescue and playful introduction of molecular techniques"	TemplateRepresentative	Classical Genetics	MOREIRA (2008)
"Use of the game 'Amino acid salad' for the understanding of the degenerate genetic code"	TemplateRepresentative	Molecular genetics	FERNANDES (2011)

Source: adapted from Hermann (2013)

Thus, considering that the teacher, in the interactionist environment, has the function of mediating the resources that lead the student to knowledge and exploring the various cognitive abilities of the students, which vary between each one, the use of games is an alternative to break with the routine of the teaching and learning process.

2.2 THE USE OF APPLICATIONS, ELECTRONIC GAMES AND SCIENTIFIC SOFTWARE AS MEDIATORS AND FACILITATORS OF THE PEDAGOGICAL PROCESS IN THE TEACHING OF BIOLOGY

2.2.1 Applications

Apps have played a key role in the field of education, providing significant benefits to the teaching process. Crompton et al (2016), conducted a review on mobile learning in the area of science, exploring the scope, purpose and extent of research activity in this field. In this study, positive results were revealed in relation to learning, regardless of the specific objectives of the research.

According to Sutisna et al (2020), the use of smartphones can facilitate the teaching-learning and evaluation process for teachers and students. However, the work warns of the impact of smartphone use, which can lead students to have less focus on the teaching and learning process.

These papers highlight the relevance and potential of mobile learning as an effective approach to advancing scientific knowledge and improving students' understanding. However, it is important to emphasize the role of the teacher as mediator of this process so that the dispersion does not end up promoting a contrary sense of the desired goal, which is learning.

In Chart 6 it is possible to observe several applications that can be used in the process of teaching biology in various themes.

Table 6 – List of applications on biology for android and ios

Name	Description	Platforms		Soon
		Ios	Android	
Digital Biology	High School Biology Exercises	x	x	
LookBio - Biology	General biology content and exercises	x	x	
Glossary of Biology	Expressions used in the biological sciences		x	
Total Biology - Video lessons	Video lessons of preparation for ENEM and Vestibulares		x	
Cells	Presentation of content focused on cytology	x	x	
Biology 100 Exercises	Questions about biology		x	
BioApp Pro	Biochemistry Contents		x	
RevisApp	Disciplines charged in High School, Enem and other Vestibular	x	x	
Biology Vestib ENEM Edilson	Biology subjects for college entrance exams	x	x	
Protein Synthesis	Presents an interactive activity on protein synthesis	x		
The Cell	Interactive 3D cell model	x	x	
DCL 3D Biology 1 and 2	3D models of various systems, cells and DNA		x	
Cellular Respiration - A Touch of the World Collection	Cellular Respiration		x	
Khan Academy	Miscellaneous themes	x	x	

Source: Authors

2.2.2 Video Games

The electronic games aimed at teaching biology in Portuguese, as well as the applications, also present low variety (Chart 7). Of the video games (for mobile devices and computers), only two of them are available for computer (Genetics Show and Friend), which, despite having been published, have not you can find the installers of them. Other games involving biology that were possible to be installed were the Biology Quiz and Biology Words & Quiz, which as the name proposes, are only questions and answers. The application The Cell, mentioned above, has a game module in Quiz format

(questions and answers) but, in addition to needing to create an account to use this feature, during the test it crashed at the time of use and the application had to be restarted several times.

Table 7 – List of video games focused on biology

Name	Description	Platforms		Soon
		Android	PC	
Biology Quiz	Questions about Biology in general	x		
Genetics Show: an interactive game for high school. MARTINEZ (2008)	Promote the diffusion and popularization of science using as a tool the recent advances in Genetics and Molecular Biology.		x	-
Amigoacids: a playful proposal for the teaching of molecular biology. VICTORY (2018)	Educational game that aims to help high school and elementary school students to expand their knowledge in the discipline of molecular biology in a playful and fun way		x	-
Biology - Words & Quiz	Assist users in learning the meaning of words related to biology.	x		

Source: Authors

2.2.3 Scientific Software

Several scientific softwares are useful for the study and teaching of biology. These softwares cover a wide range of areas, such as visualization and modeling of molecular structures, alignment of DNA and protein sequences, search for similar sequences in databases, analysis and visualization of phylogenetic data, analysis of genetic sequences, programming and analysis of biological data, visualization and analysis of biological networks, processing of biological images, and analysis of protein stability. These softwares are available on different platforms and offer varied features to assist researchers and professionals in the field.

In any case, although they were not designed for teaching, these softwares appear as tools with high potential to complement the teaching of Biology contents and incite in students the perception of how vast the applicability of scientific technologies are. The goal is to encourage not only a better assimilation of content, but also, through the introduction of students to such software, to deepen their own understanding of the meaning of science (scientific concepts) and the principles that govern it (processes, practices and critical thinking).

Some examples include PyMOL and UCSF ChimeraX for visualization and molecular modeling, Clustal Omega for sequence alignment, BLAST for searching for similar sequences, MEGA for phylogenetic analysis, Geneious for genetic sequence analysis, R and Biopython for programming

and data analysis, Cytoscape for visualization of biological networks, ImageJ for image processing and oldX for protein stability modeling and analysis.

Such software plays a fundamental role in the advancement of research and in supporting teaching and learning in the area of biology, and can be used without the need for large computational resources, being well adapted to the reality of schools where, usually, there is little availability of computers and / or computers with simpler configurations. In addition, the vast majority of the software listed here has a free license and, when not, offer academic licenses, once again facilitating its use. The software in question can be seen in Chart 8.

Table 8 – List of scientific software to support the teaching of biology

Software	Description	Platform	License	Languages	Reference
PyMOL	Molecular structure visualization and modeling software	Windows, macOS, Linux	Commercial	Several	(SCHRÖDINGER, LLC, 2015)
UCSF ChimeraX	Molecular structures visualization and analysis tool	Windows, macOS, Linux	Gratuitous	English	(PETTERSEN et al., 2021)
Clustal Omega	DNA and protein sequence alignment tool	Browser	Gratuitous	English	(GOUJON et al., 2010; SIEVERS et al., 2011)
BLAST	Algorithm for searching for similar sequences in databases	Browser	Gratuitous	Several	(MADDEN, 2003)
MEGA	Software, phylogenetic data analysis and visualization	Windows, macOS, Linux	Gratuitous	English	(TAMURA; STECHER; KUMAR, 2021)
Geneious	Bioinformatics platform that offers several tools for genetic sequence analysis	Windows, macOS, Linux	Commercial	Several	(KEARSE et al., 2012)
R	Programming language and statistical environment used for biological data analysis	Windows, macOS, Linux	Free	Several	(TIERNEY, 2012)
Biopython	Python programming library for biological data processing	Windows, macOS, Linux	Open source	English	(COCK et al., 2009)
Cytoscape	Visualization and analysis tool for biological networks	Windows, macOS, Linux	Free	Several	(SHANNON et al., 2003)
ImageJ	Image processing software used for biological image analysis	Windows, macOS, Linux	Open source	Several	(SCHNEIDER; RASBAND; ELICEIRI, 2012)

oldX	Protein stability modeling and analysis software	Windows, macOS, Linux	Commercial	English	(SCHYMKOWITZ et al., 2005)

Source: Authors

3 CONCLUSION

This review identified a variety of useful scientific software for studies in biology, covering diverse areas and offering specific resources and tools. These softwares play a key role in the advancement of research and also have the potential to complement the teaching of biological contents, offering a number of advantages, such as availability on different platforms and the possibility of use without large computational requirements, which makes them accessible in educational environments with limited resources. In addition, most of the software presented has free or academic licenses, making it easier for teachers and students to use them. However, despite the potential of these tools, it is important to note that their use is still limited in the context of teaching biology, and many teachers may not be familiar with these technologies. Therefore, it is necessary to promote the awareness and training of educators so that they can make the most of these digital resources and enrich the teaching-learning process in the area of biology, including contributing to the understanding of what it is to "do science".

In short, the integration of applications, digital games and scientific software in the teaching of biology represents a valuable opportunity to improve the understanding of concepts and stimulate the interest of students, providing a more dynamic and interactive approach, essential for current times.

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