ACTIO: Docência em Ciências
ISSN: 2525-8923

http://periodicos.utfpr.edu.br/actio

# Use of mind maps to assess the educational potential of a two-dimensional DNA replication didactic model

**Danyelle de Paula Martins Barros**
danyeliipaula@yahoo.com.br
orcid.org/0000-0003-0993-277X
Instituto Federal de Educação, Ciência e Tecnologia Fluminense Campus Campos Centro (IF Fluminense), Campos dos Goytacazes, RJ, Brasil

**Natalia Deus de Oliveira Crespo**
natalia.crespo@iff.edu.br
orcid.org/0000-0002-4718-2396
Instituto Federal de Educação, Ciência e Tecnologia Fluminense Campus Campos Centro (IF Fluminense), Campos dos Goytacazes, RJ, Brasil

## ABSTRACT

Due to their complexity and abstract nature, some biology themes become major learning obstacles and a challenge for teacher didactics. To facilitate the teaching and learning process, different resources can be used, for example, the use of didactic models. The aim of this study was to evaluate the interference mediated by the structured didactic sequence for the application of the two-dimensional DNA replication didactic model among high school students, through the analysis of mind maps. Information was collected from the educational processes incited in the students when interacting with the proposed model through a descriptive qualitative study. We highlight that this study presents a methodological data collection and analysis innovation through the use of mind maps. Students were interested, motivated and interacted significantly during all meetings and our results suggest a positive interference of the use of the proposed two-dimensional model for learning and consolidating the DNA replication theme. The maps measured after the use of the didactic model were multistructural, containing more illustrations and texts related to the theme, while also obtaining higher scores. It is concluded that the use of mind maps is a viable and complete instrument to evaluate the cognitive process of students during their learning construction, and we note that the proposed two-dimensional DNA replication didactic model confirms the feasibility and advantages of using active and playful activities in teaching/learning promotion by facilitating concrete visualization/handling to understand abstract structures and concepts related to different science areas.

**KEYWORDS:** DNA synthesis. Didactic models. Mind maps.

## INTRODUCTION

Many students present learning difficulties regarding Biology contents. Several authors have sought out answers to these difficulties and attribute this problem to different reasons, such as pedagogical obstacles associated to teaching strategies, public policies related to education, lack of school structure and problems related to teacher education (TANAJURA, 2017). Dias, Nunes and Ramos (2010), when assessing biology test results, concluded that students present the greatest difficulties concerning contents comprising the cell, biotechnology and genetics.

Difficulties regarding the genetic language are attributed to the fact that this field displays a vast and complex vocabulary, leading most students to not understand and differentiate genetic concepts. In addition, these contents are usually covered in separate topics and their relationships are rarely integrated by teachers, leading students to establish these connections on their own (CID; NETO, 2005).

Despite the curricular segmentation observed in several biological disciplines, Cell Biology teaching and its concepts should be approached in an interdisciplinary manner, in order to construct meanings regarding the diversity of life (VIGARIO; CICILLINI, 2019). The maintenance and continuity of life depends on the cell's ability to store, obtain and translate genetic instructions, which are subsequently transferred during the cell division process (REECE et al., 2015). Thus, genetic material (deoxyribonucleic acid - DNA) replication must be reliable, leading to subsequent gene distribution to two daughter cells (ALBERTS et al., 2017; NEPOMUCENO et al., 2017). The high accuracy of this process is verified by low DNA mutation rates, contributing to an unchanged genome (ALBERTS et al., 2017). To this end, helicases, polymerases and other proteins move along DNA strands and perform DNA replication, ensuring the correct transmission of genetic instructions from one generation to the next (NELSON; COX, 2014).

Faced with educational obstacles, several resources can be applied to stimulate student learning and to overcome the abstraction of basic Science concepts, such as the use of illustrated teaching materials, playful activities and computational resources, among others (TANAJURA, 2017). According to Guimarães et al. (2016), didactic models and playful games comprise the pedagogical interventions that most contribute to meaningful learning. Therefore, their use is indicated as a teaching differential, as they are able to unite theory and practice, leading to interactive classes which, in turn, stimulate student participation and creativity (FONTENELLE; CAMPOS, 2017; ZAPATEIRO et al., 2017). The use of didactic models presents several advantages, such as the ability to develop student creative capacity, materialize certain concepts and assist in knowledge construction, among others (ALEXANDRE; MENDONÇA, V.; MENDONÇA, M., 2017).

When using models, the teacher must clarify that they comprise simplified representations of a real object or a dynamic process (ALMEIDA; LORENCINI-JÚNIOR, 2018; LAZZARONI; TEIXEIRA; MEGID NETO, 2017). In addition, in order to use models in the classroom, the teacher must stimulate students to explore them and, thus, build their own knowledge (RAMOS; SANTOS; LABURÚ, 2017; SILVA et al., 2012). Consequently, several model benefits and their effectiveness are noted in the learning process, both for students, who become interested in learning, and teachers, who can assist students more effectively and monitor the results of their work (NICOLA; PANIZ, 2016).

Associated to new learning resources, mind maps favor thought organization in a simple and easy way. According to Buzan (2005, p. 24), they are “the easiest way to introduce and extract information from the brain –a creative and effective way of taking notes that literally 'map' your thoughts”. Thus, when drawing up a mind map, students are able to transform their ideas into an organized and colorful diagram, easy to memorize and operating in harmony with natural brain functioning (BUZAN, 2005). In addition to assisting in student learning, mind maps can be used by teachers as learning assessment instruments associated with other evaluative tools (MARQUES, 2008).

In this context, the aim of the present study was to evaluate the interference mediated by a didactic sequence (DS) structured for the application of a two-dimensional DNA replication didactic model among high school 3rd grade students, through mind map analyses. Information was obtained from the educational processes encouraged in the students when interacting with the proposed model, through a descriptive qualitative study. Motivated by the abstraction of the studied theme, we used mind maps created by the students before and after the DS interference, in order to acquire qualitative data (BUZAN, 2005), while also describing student observations and interactions promoted by model handling. Some criteria were developed to assist in the mind map correction process, due to the absence of literature references to support the applied analyses.

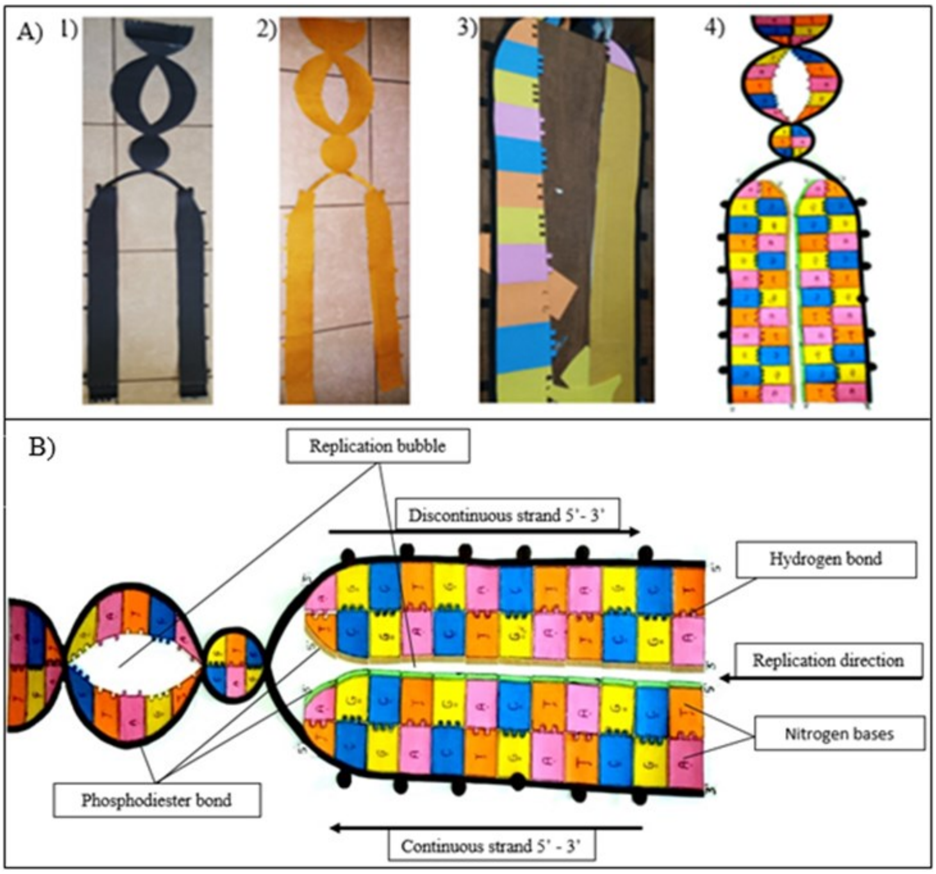
## METHODOLOGY

This paper comprised a qualitative descriptive study (DENZIN; LINCOLN, 2005; NEVES, 1996) with the aim of presenting the interactions and educational processes resulting from the use of a two-dimensional DNA replication didactic model applied in a DS intended for high school students. The DS activities organized for the two-dimensional didactic model application were ordered, structured and articulated alongside educational objectives in order to elucidate DNA replication process concepts and mechanisms (ZABALA, 1998). During the didactic model application, different concepts associated to the functional performance of active proteins and enzymes for correct DNA replication were addressed, namely helicase, topoisomerase, SSBP (Single Strand Binding Proteins), primase, polymerase I and III and ligase. Student evolution during the applied DS using the proposed model was monitored through photos and oral discussion records. In addition, mind map comparisons were applied to record conceptual progress (BUZAN, 2005) concerning DNA replication before and after the DS.

The didactic DNA replication model proposed herein was developed using low-cost materials, such as reused banner canvases and cardboards to prepare the double DNA strand and represent replication bubbles, coated with colored EVA (Vinyl Acetate Ethylene) cut into the shape of puzzle pieces (8cm x 6.5 cm) to exemplify the four nitrogen bases (Figure 1), where A) refers to the production stages, categorized as 1) Cut panel canvas; 2) Cut cardboard paper; 3) Assembly of

EVA nitrogen bases and 4) Finished didactic model. Finally, B) represents the complete didactic model containing the description of each structure.

Figure 1 – Stages for the preparation of the two-dimensional didactic DNA replication model




Source: The authors (2020).

Each nitrogen base piece was prepared in a specific color, i.e. orange for thymin and uracil, pink for adenine, blue for cytosine and yellow for guanine. The initial of each nitrogen base name was also written in a capital letter, as T, U, A, C and G, respectively. Each piece also contained a cutout representing hydrogen bonds, totaling three cutouts for the bonds between cytosine and guanine and two between thynine and adenine and thymin and uracil. To represent the 5' - 3' phosphodiéster bonds between triphosphated deoxynucleotides and the forming strand catalyzed by polymerase, the model was prepared using a continuous EVA strand, black for old strands and green and beige color for newly synthesized strands, termed continuous and discontinuous, respectively. In addition, the model includes the identification of the direction in which the mold strands are organized and the direction for new strand syntheses (5' – 3'), through the insertion of EVA containing the numbers (5') and (3') at the ends of the first and last nucleotides, including primers, which make up the mold strands and the newly synthesized ones.

The complete didactic model contains a total of eighty-two interactive pieces, seventy representing the nitrogen bases, which comprise four pieces with the same characteristics, with red representing the primer. Seven pieces display different formats to exemplify the proteins and enzymes that participate in the replication process (SSBP, primase, topoisomerase, ligase, helicase, polymerase I and III), and one white piece is used to locate the Okazaki fragments present in the discontinuous strand.

The model material contains conceptual information that allows for different knowledge degrees to be applied by the teacher. In this regard, three different difficulty application levels are proposed herein, namely basic, medium and advanced. The basic level was organized according to the contents presented in books aimed to the 3rd high school grade of public schools, such as Clézio and Bellinello (2003), Amabis and Martho (2001) and Linhares, Gewandsznajder and Pacca (2017). The medium level contents were based on books aimed at the 3rd high school grade of private schools (COC Handout, 2019), while the advanced level was based on Higher Education Biology books (Alberts et al., 2017). Table 1 presents the concepts relating to each previously structured application level.

Table 1 – Theoretical concepts associated to the different didactic DNA replication model application levels

| | Level | | |
|---|---|---|---|
| **Content** | **Basic** | **Medium** | **Advanced** |
| 1- DNA as genetic material. | X | X | X |
| 2- Chemical composition of the DNA molecule. | X | X | X |
| 3- The DNA molecule is a double helix. | X | X | X |
| 4- DNA replication is semi-conservative. | X | X | X |
| 5- The DNA enzyme Polymerase III acts during the replication process. | X | X | X |
| 6- The enzymes helicase, polymerase I, primase and ligase act during the replication process. | | X | X |
| 7- The enzyme topoisomerase acts during the replication process. | | | X |
| 8- Single Strand Binding Proteins (SSBP) act during the replication process. | | | X |
| 9- The synthesis of the new strand occurs in the 5' - 3' direction. | X | X | X |
| 10- Synthesis initialization occurs by an RNA *primer.* | | X | X |
| 11- Okazaki fragments are formed In the discontinuous tape. | | X | X |
| 12- Amount of hydrogen bond between nucleotides. | | X | X |

Source: The authors (2020).

The two-dimensional didactic model was applied through a DS structured for three meetings comprising one hour/class each, in 3rd grade high school classes in one private school and in two federal schools, in 2019. The intentions, purpose and procedures of this study were presented at the beginning and during the DS, always respecting and preserving all subjects. All the data described herein guarantee participant anonymity.

During the first meeting, students were briefly instructed on the production of mind maps, according to the rules established by their creator, Buzan (2005), including paper sheets used in the landscape position, central words and the use of colors, drawings and keywords. Subsequently, the students were asked to prepare a mind map for 15 minutes on the theoretical concepts related to the DNA replication process, i.e. by placing the "DNA Replication" term as central, associated to the functions of each enzyme, as well as the process organization, DNA molecule composition and other relevant information.

The second DS meeting began with an initial theoretical exposition on the entire DNA duplication mechanism, addressing concepts concerning DNA molecule structure and composition, replication forks, enzyme action and the meaning of synthesis and error repair mechanisms. The proposed activity comprised model handling for the assembly of a new DNA strand in the correct sequence, according to the level of difficulty chosen by the head teacher. Some students were selected to act as the enzymes who, according to their functions, assist in the assembly of the new DNA strand in the correct order of action. We proposed that all students participate in the new DNA strand synthesis, collectively helping in the assembly and explanation of the functions of each enzyme.

During the third meeting, after didactic model investigation and handling, all students were asked to produce a new mind map containing DNA replication concepts and processes. Student verbal expressions (collected through audio recordings), interactions, participation and motivations concerning the model and the mind maps produced before and after the replication theme study using the two-dimensional didactic model are part of the data collected herein.

Three correction criteria were elaborated to analyze and select the learning indicators presented in the mind maps developed after the DS application. No students knew how the maps would be corrected during the DS. Moreira's (1984) article entitled: "The Conceptual Map as a Learning Assessment Tool" was used as basis to structure the applied criteria, organized into three major categories: 1) Concepts, 2) Concept structure and 3) Concept hierarchy. Subcategories were created within each category, to better extract the information present in each produced mind map, so each student production could be evaluated and a score assigned when a concept was adequately represented in the mind maps. Each each mind map could total 10.0 points, as displayed in Table 2.

Table 2 – Criteria applied for mind map evaluations and their respective scores

| 1- Concept | Scores | Total |
|---|---|---|
| a) Cycle phase | 0.5 | 5.0 |
| b) Enzymes: helicase, ligase, primase, DNA polymerase I and III, topoisomerase and SSBP | 0.5 | |
| c) DNA as a double stranded genetic material | 0.5 | |
| d) Chemical composition (phosphate, sugar and nitrogen base) | 0.5 | |
| e) Semi-conservative replication | 0.5 | |
| f) 5'-3' strand direction | 0.5 | |
| g) RNA primer | 0.5 | |

| | | |
|---|---|---|
| h) Discontinuous strand | 0.5 | |
| i) Okazaki fragments | 0.5 | |
| j) Hydrogen bond between nitrogen bases | 0.5 | |
| **2 –Concept structure** | | |
| k) Concept structuring | 1.0 | 3.0 |
| l) Concept differentiation | 1.0 | |
| m) Relationship between concepts | 1.0 | |
| **3 –Concept hierarchy** | | |
| n) Beginning | 0.5 | 2.0 |
| o) Middle | 0.5 | |
| p) End | 0.5 | |
| q) Replication drawing | 0.5 | |
| | | 10.0 |

Source: The authors (2020).

## RESULTS AND DISCUSSION

### MODEL APPLICATION

The three DS application meetings in the private school took place during two consecutive weeks. A total of 38 students participated in the first meeting, when A4 sheets were distributed for them to produce their mind maps concerning the DNA replication process.

The second meeting took place one day after the first meeting and was initiated with a blackboard summary in a mind map format concerning the DNA replication process, the enzymes that act in the process and their respective functions, in addition to a brief contextualization about cancer caused by mutations during the replication process, from 2015 news available in the G1 blog, at http://g1.globo.com/pop-arte/cinema/noticia/2015/03/angelina-jolie-retira-ovarios-por-medo-de-cancer.html. After contextualizing the theme and a discussion, the didactic DNA replication model was applied, addressing the contents referring to the middle difficulty level described in Table 1. The students organized the portfolios in a circle, the model was placed in the middle of the room floor and some students were chosen to represent the enzymes and act in the model by assembling the pieces representing the synthesis of new DNA strands. Some students were embarrassed at first, but with the help of the main teacher they let this go and participated in the process dynamics. Figure 2 displays the records made during the classes, where A) indicates the private school students; B) indicates federal network students from the Integrated High School Technician Course in Mechanics and C) indicates students from the Integrated High School Technician Course in Electrotechnics.

Figure 2 - Use of the two-dimensional DNA replication didactic model by 3rd grade high school students


Source: The authors (2020).

The meetings with students from the federal network took place during their mechanics classes throughout consecutive weeks and in the electrotechnical class, on alternate weeks. The first meeting contained the same initial guidance on mind map production and the preparation of the DNA replication process. Subsequently, a summary in the form of a mind map was presented on the blackboard concerning the entire replication process, the enzymes that participate in the process and their respective functions.

A total of 20 students were present in both federal network classes during the second meeting, where the model was applied at the advanced level, with teacher orientation and supported by the fact that the content of this theme had already been addressed at this level. In the electrotechnical class, an extra application time was used to test the model as a didactic game, where the replication model and its parts, including the enzymes, were scattered on the floor and the class was separated into two groups, A and B. The game comprised each group assembling the model in the least time possible while following all correct replication process stages, respecting the action of each enzyme and placing their parts in the model during assembly to represent their performance. If the assembly was performed incorrectly, not following the replication sequence, the students would have to repeat the step. Group A was able to accomplish the task in less time than group B. Students were motivated, nervous/anxious and interested in participating.

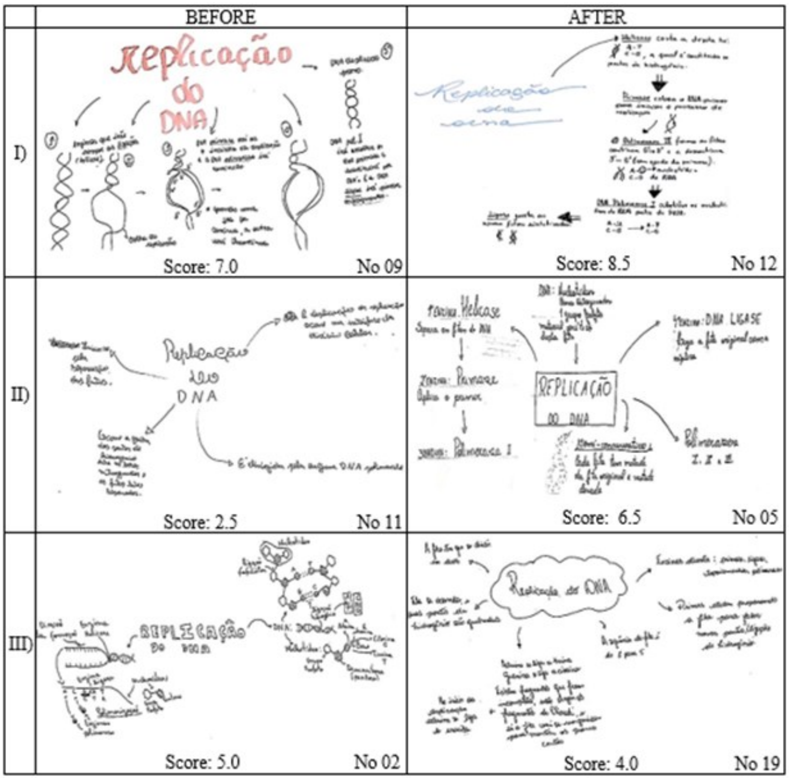
## PRODUCED MIND MAPS

All mind maps produced by students from both schools were analyzed according to the previously described criteria. Each mind map produced before and after the didactic model applications received an increasing and random score according to the class, where the numbers were broken down into the before and after products and do not correspond to the same student, as students did not identify themselves in the maps.

A total of 141 mind maps were produced, 73 from the private network, 33 from the federal education network mechanics class and 35 from the federal education network electrotechnics class. Some are exemplified in Figure 3, with their respective scores. The maps on the left represent initial student productions, and those on the right, produced after the use of the didactic model, both of which display higher scores according to the criteria analyses. The map number and the total score breakdown are displayed below each image.

The mind map analysis indicates that more connections were noted after didactic replication model applications, integrating the discussed concepts. In addition, the diversity of the productions confirms the nonlinearity and the various mind paths that each student used to weave their knowledge (ALVES; GARCIA, 2000), which favor content memorization and fixation (BUZAN, 2005). Figure 3 exhibits I) the private network, II) Federal Network - Integrated High School Technician Course in Mechanics and III) Integrated High School Technician Course in Electrotechnics.

Figure 3 – Higher-scoring mind maps produced by students before and after the use of the didactic model




Source: The authors (2020).

Some students represented the replication process in a very similar manner to the two-dimensional didactic model, demonstrating memorization of the way the model was elaborated/handled/applied, aiding in content understanding. Some students also represented the design of other important structures associated to the replicative process, such as the nucleotide, the replication fork, scissors to illustrate helicase action, and a clock to mark the cell cycle period when DNA replication occurs. However, many students still exhibited significant difficulty in representing the process through drawings, as they say they do not know how to draw. Nevertheless, drawings, symbols and words, among others, are important learning mental analogies, assisting in content memorization and association (BUZAN, 2005).

## MIND MAP ANALYSES

The mind maps presented in Figure 3 were corrected according to the aforementioned criteria and subcriteria and selected for score discrimination presentation (Table 4).

Maps produced by students from both the private network and from the mechanics course displayed a higher performance after the use of the didactic model. On the other hand, the highest score obtained by the maps prepared by the students of the electrotechnical course was 4.0, exhibiting the absence of a hierarchy between concepts, the third evaluated category. This result was lower when compared to the maps produced before the model application. We assume that the choice of an advanced level didactic model application in the federal network classes interfered with these data, resulting in a lower mean score, since the level of difficulty was higher when compared to the private school class. In addition, the initiative to evaluate model application through mind map preparation may have also been a source of interference.

Table 4 - Discrimination of the mind maps presenting the highest scores produced by students before and after didactic model application according to the previously established categories and subcategories

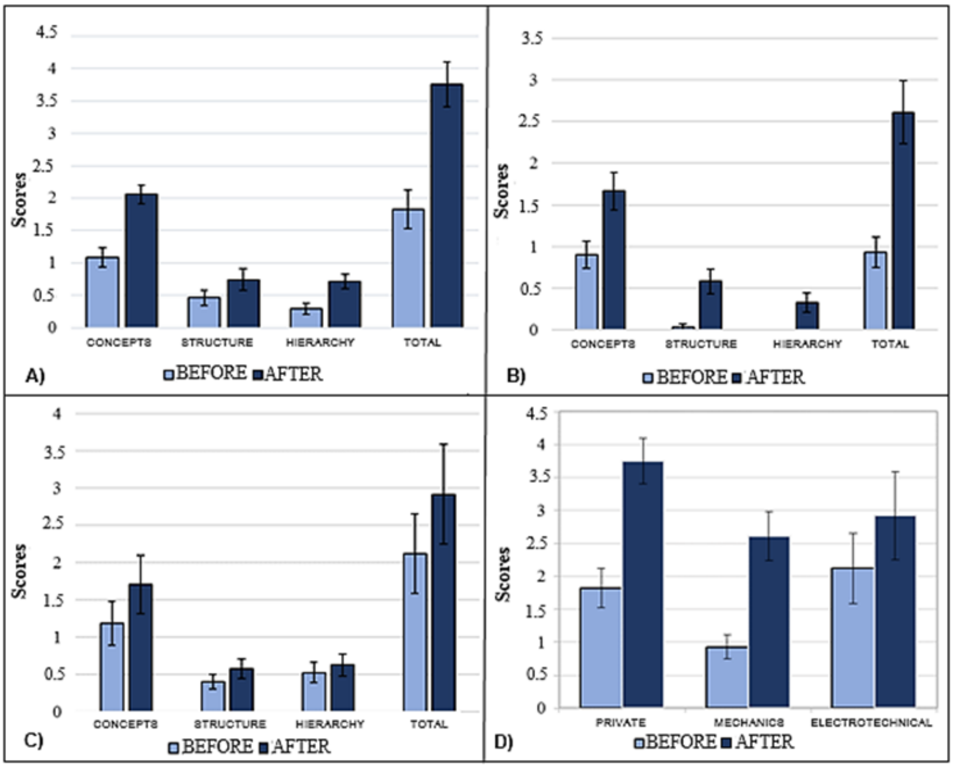
| Cat. | Sub. | Private | | Mechanics | | Electrotechnics | |
|---|---|---|---|---|---|---|---|
| | | Before (no. 09) | After (no. 12) | Before (no. 11) | After (no. 05) | Before (no. 02) | After (no. 19) |
| Concepts | a) | 0 | 0 | 0,5 | 0 | 0 | 0 |
| | b) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | c) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0 |
| | d) | 0 | 0.5 | 0 | 0.5 | 0.5 | 0.5 |
| | e) | 0 | 0 | 0 | 0.5 | 0 | 0 |
| | f) | 0.5 | 0.5 | 0 | 0.5 | 0 | 0 |
| | g) | 0 | 0,5 | 0 | 0.5 | 0 | 0.5 |
| | h) | 0.5 | 0.5 | 0 | 0 | 0 | 0 |
| | i) | 0 | 0 | 0 | 0 | 0 | 0.5 |
| | j) | 0 | 0.5 | 0.5 | 0 | 0.5 | 0.5 |

| Cat. | Sub. | Private | | Mechanics | | Electrotechnics | |
|---|---|---|---|---|---|---|---|
| | | Before (no. 09) | After (no. 12) | Before (no. 11) | After (no. 05) | Before (no. 02) | After (no. 19) |
| Structure | k) | 1.0 | 1.0 | 0 | 1.0 | 0.5 | 0.5 |
| | l) | 1.0 | 1.0 | 0.5 | 0.5 | 0.5 | 0.5 |
| | m) | 1.0 | 1.0 | 0 | 1.0 | 0.5 | 0.5 |
| Hierarchy | n) | 0.5 | 0.5 | 0 | 0.5 | 0.5 | 0 |
| | o) | 0.5 | 0.5 | 0 | 0 | 0,5 | 0 |
| | p) | 0.5 | 0.5 | 0 | 0.5 | 0 | 0 |
| | q) | 0.5 | 0.5 | 0 | 0 | 0.5 | 0 |
| Total | | 7.0 | 8.5 | 2.5 | 6.5 | 5.0 | 4.0 |

Source: The authors (2020).

All 141 maps obtained before and after the didactic model application were evaluated and the general means obtained after their correction from each previously described criterion in the three major categories are presented in Figure 4, as follows: 1) concepts, 2) concept structure and 3) concept hierarchy. A score increase was noted in all classes after the use of the didactic model, demonstrating the influence of this methodology on the learning of DNA replication content. The private network students achieved the highest scores. The slight variations in the overall score between the mind maps prepared before and after the DS in the Integrated High School Technician Course in Electrotechnics suggest that the students exhibited previous knowledge related to the applied theme.

Figure 4 – Mean mind map scores of maps produced by private network students (A) and federal network students from the mechanics course (B), electrotechnical course, (C) and the sum of the general total (D) of the classes in the concept, structure and hierarchy




Source: The authors (2020).

General mind map data (Figure 4-D) indicate an increase in the score means of all evaluated criteria after the didactic model application, indicating that the two-dimensional didactic model positively interfered in DNA replication content learning.

A general qualitative data analysis concerning the procedural development of the evaluated students was performed in an attempt to delimit limits and possibilities achieved by the use of the didactic DNA replication model presented herein (TEIXEIRA; MEGID NETO, 2017). Thus, some student statements when asked about model use and improvements were recorded. Some private network student statements were: student A: "Interesting, because [...] when using pictures we do not understand the essence of the process and, here, we're assembling it [...] I'm even able to better understand the discontinuous strand [...]"; Student B: "It's much easier when you see what you see on the board is put into practice [...]". In the federal mechanics class: student C indicated that "It is much better, because when the teacher puts the process on the television it's not clear, but seeing the process using the model made it easier to identify each step."; student D: "It was very dynamic. I liked it because everyone participated, and it was very interactive."; student E: "Give us more models"; Student F: "Separate the group class and see who will assemble the model first and then give a box of chocolates to whoever wins." In the electrotechnical class, student G indicated that "I liked it very much, mainly because the entire class participated and it was more dynamic and a different approach to understand the whole question of how duplication works [...], making understanding is easier."; student H: "That competition was cool because the staff [...] felt interested in participating [...]. " In general, the students expressed that they liked the model and stated that it facilitated learning the proposed contents.

The use of didactic models in the classroom has proven to be a strategy for the theoretical exposition of textbooks (ORLANDO et al., 2009; REZENDE; GOMES, 2018), complementing traditional classes based only on content transmission (PORLÁN-ARIZA; RIVERO, 1998) contributing to student creativity, imagination, enthusiasm, collective participation and active interactions, in addition to knowledge assimilation (AMADOR et al., 2018). The data presented herein indicate that the use of a two-dimensional didactic replication model positively influenced student learning, corroborating Fontenele and Campos (2017) who also applied a DNA structure model. Those authors point out that "According to studen' answers, the didactic DNA structure model was enlightening concerning doubts associated to the addressed theme", and that "the didactic model, besides improving the understanding of the subject, made the class more interesting and escaped the traditional teaching to which students are accustomed to."

## CONCLUSIONS

The results reported in the present study demonstrate student interest in handling the two-dimensional didactic model applied herein, in addition to resulting in motivation and interactions. The mind maps produced after the didactic sequence contained more drawings and texts related to the theme, demonstrating a multistructural construction through various mental paths that each student used to elaborate their DNA replication knowledge (ALVES; GARCIA, 2000; BIGGS; TANG, 2011).

We also emphasize that the criteria elaborated for the mind map assessments are important, since they favor the evaluation of significant mind map diversity and comprise a methodological innovation for mind map analyses and evaluations. The importance of using mind maps as a potentiator for student learning is also noteworthy, since this methodology improves learning, facilitating these types of studies.

Finally, this study demonstrates the feasibility and advantages of using differentiated activities in teaching/learning promotion by DS, using a didactic DNA replication model. Models are significant teacher allies able to complement theoretical expositions and arouse student interest, since they favor the visualization of abstract structures and concepts, improving school performance.

# Uso de mapas mentais para avaliação do potencial educativo do modelo didático bidimensional sobre replicação do DNA


## RESUMO

Alguns temas de biologia, por serem complexos e abstratos, acabam se tornando grandes empecilhos no aprendizado, sendo um desafio para a didática dos professores. Para facilitar o processo de ensino e aprendizado diferentes recursos podem ser utilizados, como exemplo, o uso de modelos didáticos. O objetivo deste trabalho foi avaliar por meio da análise de mapas mentais a interferência mediada pela sequência didática estruturada para aplicação do modelo didático bidimensional sobre replicação de DNA entre discentes do Ensino Médio. Através de um estudo qualitativo descritivo, foram coletadas informações dos processos educacionais incitados nos estudantes ao interagirem com o modelo proposto. Destacamos que este trabalho apresenta uma inovação metodológica de coleta de dados e análise por meio dos mapas mentais. Verificou-se que os alunos demonstraram-se interessados, motivados e interagiram bastante durante todos os encontros e, nossos resultados sugerem interferência positiva do uso do modelo bidimensional proposto para o aprendizado e consolidação do tema da replicação do DNA. Os mapas aferidos após o uso do modelo didático apresentaram-se multiestruturais, com mais ilustrações e textos relacionados ao tema além de obterem maior pontuação. Conclui-se que o uso de mapas mentais é um instrumento viável e completo para avaliar o processo cognitivo dos alunos na construção de seu aprendizado e, destacamos que o modelo didático bidimensional de replicação do DNA proposto confirma a viabilidade e vantagens de utilização de atividades ativas e lúdicas na promoção do ensino/aprendizagem por facilitar a visualização/manuseio concreto para entendimento de estruturas e conceitos abstratos relacionados a diferentes áreas da ciência.


**PALAVRAS-CHAVE:** Síntese do DNA. Modelo didático. Mapas mentais.

## ACKNOWLEDGMENTS

The authors would like to thank the Campos Centro Federal Institute of Education, Science and Technology Fluminense Campus (IF Fluminense), Campos dos Goytacazes, RJ, Brazil. They also acknowledge the Professor Clovis Tavares, from Pró-Uni College, for his availability to apply this study.

## REFERÊNCIAS

ALBERTS, B.; JOHNSON, A.; LEWIS J.; RAFF, M.; BRAY, D.; HOPKIN, K.; et al. **Biologia Molecular da Célula**. 6 ed. Porto Alegre: Artmed, 2017.

ALEXANDRE, J. S.; MENDONÇA, V. A.; MENDONÇA, M. C. F. B. Construção de Modelo Didático para o Ensino de Ciências: sistema urinário. **Experiências em Ensino de Ciências**, Mossoró, v. 12, n. 7, p. 100-107, 2017. Disponível em: http://if.ufmt.br/eenci/artigos/Artigo_ID425/v12_n7_a2017.pdf. Acesso em: 30 mai. 2020.

ALMEIDA, H. A.; LORENCINI-JÚNIOR, A. As concepções de um professor de Biologia quanto ao uso de analogias na prática docente. **ACTIO:** Docência em Ciências, Curitiba, v.3, n.2, p.173-194, mai./ago. 2018. Disponível em: https://periodicos.utfpr.edu.br/actio/article/view/8085/5285. Acesso em: 06 nov. 2020.

AMABIS, J. M.; MARTHO, G. R. **Conceitos de Biologia.** São Paulo: Editora Moderna, v. 3, 2001.

AMADOR, N. L.; TRINDADE, R. J.; GOMES, P. W. P.; RAMOS, E. Z.; SOUZA, R. F. Estratégia didática: utilizando a modelagem para facilitar o ensino e aprendizagem da temática terra e universo. **ACTIO:** Docência em Ciências, Curitiba, v.3, n.3, p.26-42, 2018. Disponível em: https://periodicos.utfpr.edu.br/actio/article/view/7565/5622. Acesso em: 30 mai. 2020.

ALVES, N.; GARCIA, R. L. Pra começo de conversa. *In:* ALVES, N.; GARCIA, R. L. (orgs.) **O sentido da escola**. Rio de Janeiro: DP&A. p. 7 – 16, 2000.

APOSTILA DO COC. **Matemática e Ciências da Natureza, 1º e 3º ano**. Editora COC Ltda. Ribeirão Preto, São Paulo, 2019.

BIGGS, J.; TANG, C. **Teaching for Quality Learning at University.** 4 ed. Berkshire, England: Society for Research into Higher Education & Open University Press, 2011. Disponível em: https://cetl.ppu.edu/sites/default/files/publications/-John_Biggs_and_Catherine_Tang-_Teaching_for_Quali-BookFiorg-.pdf. Acesso em: 31 mai. 2020.

BUZAN, T. **Mapas mentais e sua elaboração**: um sistema definitivo de pensamento que transformar a sua vida. Tradução Euclides Luiz Calloni, Cleusa Margô Wosgrau. São Paulo: Cultrix, 2005.

CID, M.; NETO, A. J. Dificuldades de aprendizagem e conhecimento pedagógico do conteúdo: o caso da genética. **Enseñanza de las Ciencias**, n. Extra, p. 1-5, 2005. Disponível em: https://core.ac.uk/download/pdf/13303062.pdf. Acesso em: 30 mai. 2020.

CLÉZIO, M.; BELLINELLO, L. C. **Biologia**. 2 ed. rev. e ampl. São Paulo: Atual, 2003.

DENZIN, N. K.; LINCOLN, Y. A disciplina e a prática da pesquisa qualitativa. *In*: DENZIN, Norman K.; LINCOLN, Yvonna (org.). **Planejamento da pesquisa qualitativa: teorias e abordagens.** 2 ed. Porto Alegre: ARTMED, 2006.

DIAS, M. A. S.; NÚÑEZ, I. B.; RAMOS, I. C. D. Dificuldades na aprendizagem dos conteúdos: uma leitura a partir dos resultados das provas de Biologia do vestibular da Universidade Federal do Rio Grande do Norte (2001 a 2008). **Revista Educação em Questão**. Natal, v. 37, n. 23, p. 219-243, 2010. Disponível em: file:///C:/Users/deusn/Downloads/3984-Texto%20do%20artigo-9092-1-10-20130806%20(1).pdf. Acesso em: 30 mai. 2020.

FONTENELLE, M. S.; CAMPOS, F. L. Proposta de Modelo Didático como Facilitador do Ensino da Estrutura do DNA em uma Escola Pública na Região Meio Norte do Piaui, Brasil. **Revista Espacios,** v. 38, n. 45, p. 21, 2017. Disponível em: https://www.revistaespacios.com/a17v38n45/a17v38n45p21.pdf. Acesso em: 30 mai. 2020.

GUIMARÃES, E. G.; CASTRO, L. S.; BAUTZ, K. R.; ROCHA, G. L. O uso de modelo didático como facilitador da aprendizagem significativa no ensino de biologia celular. **Revista Univap,** São José dos Campos, v. 22, n. 40, p. 231-235, 2016. Disponível em: http://www.inicepg.univap.br/cd/INIC_2016/anais/arquivos/RE_1085_1024_01.pdf. Acesso em: 30 mai. 2020.

LAZZARONI, A. A.; TEIXEIRA, G. A. P. B. Construção e aplicação de um modelo tridimensional como recurso didático para o ensino de síntese proteica. **Revista de Ensino de Bioquímica**, 2017. Disponível em: http://bioquimica.org.br/revista/ojs/index.php/REB/article/view/742/0. Acesso em: 30 mai. 2020.

LINHARES, S.; GEWANDSZNAJDER, F.; PACCA, H. **Biologia Hoje**. Manual do Professor, Biologia Ensino Médio, v. 2. Editora Ática, 2017.

MARQUES, A. M. **Utilização pedagógica de mapas mentais e de mapas conceituais.** 2008. 153 f. Dissertação (Mestrado em Expressão Gráfica, Cor e Imagem apresentado à Universidade Aberta) 2008. Universidade Aberta, [*S. l.*], 2008. Disponível em: https://repositorioaberto.uab.pt/handle/10400.2/1259. Acesso em: 30 mai. 2020.

MOREIRA, M. A. **O mapa conceitual como instrumento de avaliação da aprendizagem.** [1984]. Disponível em: http://files.tecnicoembiblioteca.webnode.com/200000033-b59e9b698e/O%20mapa%20conceitual%20como%20instrumento%20de%20avalia%C3%A7%C3%A3o%20na%20aprendizagem.pdf. Acesso em: 30 mai. 2020.

NELSON, D. L.; COX, M. M. **Princípios de Bioquímica de Lehninger.** 6 ed. Porto Alegre, Artmed Editora, 2014.

NEPOMUCENO, L. L.; FERREIRA, J. L.; DE SOUZA CRUZ, V.; GABRIEL, G. M.; ARAÚJO, E. G. Mecanismos de reparo aos danos no DNA nos pontos de checagem do ciclo celular. **Enciclopédia Biosfera***,* Centro Científico Conhecer - Goiânia, v.14 n.25, p. 881, 2017. Disponível em: https://www.conhecer.org.br/enciclop/2017a/agrar/mecanismos%20de%20reparo.pdf. Acesso em: 30 mai. 2020.

NEVES, J. L. Pesquisa qualitativa: características, usos e possibilidades. **Caderno de Pesquisas em Administração**, FEA - Universidade de São Paulo, São Paulo, v. 1. n. 3, 1996. Disponível em: https://www.academia.edu/8171621/PESQUISA_QUALITATIVA_CARACTER%C3%8DSTICAS_USOS_E_POSSIBILIDADES?auto=download. Acesso em: 30 mai. 2020.

NICOLA, J. A.; PANIZ, C. M. A importância da utilização de diferentes recursos didáticos no ensino de biologia. **InFor - Inovação e Formação - Revista do Núcleo de Educação a Distância da Unesp**, São Paulo, v. 2, n. 1, p.355-381, 2016. ISSN 2525-3476. Disponível em: https://ojs.ead.unesp.br/index.php/nead/article/view/InFor2120167/pdf. Acesso em: 30 mai. 2020.

ORLANDO, T. C.; LIMA, A. R.; DA SILVA, A. M.; FUZISSAKI, C. N.; RAMOS, C. L.; MACHADO, D.; FERNANDES, F. F.; LORENZI, J. C. C.; LIMA. M. A.; GARDIM, S.; BARBOSA, V. C.; TRÉZ, T. A. Planejamento, montagem e aplicação de modelos didáticos para abordagem de biologia celular e molecular no ensino médio por graduandos de ciências biológicas**. Revista Brasileira de Ensino de Bioquímica e Biologia Molecular**, v.1, n.1, p.1-17, 2009. Disponível em: http://bioquimica.org.br/revista/ojs/index.php/REB/article/view/33. Acesso em: 30 mai. 2020.

PORLÁN-ARISA, R.; RIVERO, A. **El conocimiento de los profesores**: uma proposta en el área de ciencias. Sevilha: Diáda, 1998.

RAMOS, E. S.; SANTOS, F. A. C.; LABURÚ, C. E. O uso da ludicidade como ferramenta para o Ensino de Quimica Organica: o que pensam os alunos. **ACTIO:** Docência em Ciências, Curitiba, v.2, n.1, p.119-136, jan./jul. 2017. Disponível em: https://periodicos.utfpr.edu.br/actio/article/view/6810/4449. Acesso em: 06 nov. 2020.

REECE, J. B.; WASSERMAN, S. A.; URRY, L. A.; CAIN, M. L.; MINORSKY, P. V.; JACKSON, R. B. **Biologia de Campbell**, 10 ed. São Paulo: Artmed, 2015.

REZENDE, L. P.; GOMES, S. C. S. Uso de modelos didáticos no ensino de genética: estratégias metodológicas para o aprendizado. **Revista de Educação, Ciências e Matemática,** v. 8, n. 2, 2018. Disponível em: file:///C:/Users/deusn/Downloads/4447-13451-1-PB.pdf. Acesso em: jun. 2020.

SILVA, M.; SOARES, I.; ALVES, F.; SANTOS, M. Utilização de Recursos Didáticos no processo de ensino e aprendizagem de Ciências Naturais em turmas de 8º e 9º anos de uma Escola Pública de Teresina no Piauí. *In*: VII CONNEPI - CONGRESSO NORTE NORDESTE DE PESQUISA E INOVAÇÃO, 2012, Palmas. **Anais** [...]. Palmas, 2012. Disponível em: http://propi.ifto.edu.br/ocs/index.php/connepi/vii/paper/viewFile/3849/2734. Acesso em: 30 mai. 2020.

TANAJURA, V. S. **Dificuldades no Ensino em Biologia Celular na Escola de Educação Média**: considerações e apontamentos a partir de depoimentos de professores(as). 2017. 108 f. Dissertação (Mestrado em Educação para a Ciência - FC), Universidade Estadual Paulista, Bauru, 2017. Disponível em: https://repositorio.unesp.br/handle/11449/151028. Acesso em: 30 mai. 2020.

TEIXEIRA, P. M. M.; MEGID NETO, J. Uma proposta de tipologia para pesquisas de natureza interventiva. **Ciência & Educação**, Bauru, v.23, n.4, p.1055-1076, 2017. Disponível em: https://www.scielo.br/scielo.php?pid=S1516-73132017000401055&script=sci_abstract&tlng=pt. Acesso em: 30 mai. 2020.

VIGARIO, A. F.; CICILLINI, G. A. Os saberes e a trama do ensino de Biologia Celular no nível médio. **Ciência & Educação,** Bauru, v. 25, n. 1, p. 57-74, 2019. Disponível em: https://www.scielo.br/scielo.php?pid=S1516-73132019000100057&script=sci_arttext. Acesso em: 30 mai. 2020.

ZABALA, A. **A prática educativa**: como ensinar. Porto Alegre: Editora Artes Médicas Sul, 1998.

ZAPATEIRO, G. A.; FIGUEIREDO, M. C.; BELTRAME, A. C. F.; STEVANATO, A. Material didático como estratégia de ensino e de aprendizagem das ligações químicas. **ACTIO:** Docência em Ciências, Curitiba, v.2, n.2, p.211-233, jul./set. 2017. Disponível em: https://periodicos.utfpr.edu.br/actio/article/view/6862/4538. Acesso em: 06 nov. 2020.

**Received:** 06 Jun. 2020
**Approved:** 03 Nov. 2020
**DOI:** 10.3895/ actio.v5n3.12534
**How to quote:**
BARROS, D. de P. M.; CRESPO, N. D. de O. C. Use of mind maps to acess the educational potential of a two-dimensional DNA replication didactic model. **ACTIO**, Curitiba, v. 5, n. 3, p. 1-23, set./dec. 2020. Available at: <https://periodicos.utfpr.edu.br/actio>. Access at: XXX
**Correspondence:**
Natalia Deus de Oliveira Crespo
Rua Dr. Siqueira, 273 - Parque Dom Bosco, Campos dos Goytacazes - RJ, CEP 28030-130, Brazil.