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Use of models in pedagogical practice for teaching cell biology[1]

Tályta Carine da Silva Saraiva[2]
Jorge Diniz de Oliveira[3]

ABSTRACT

The use of models in Biology teaching provides a practical approach to understand cellular structures, offering a comprehensive view of cell diversity. This study investigates the benefits and challenges of this strategy, highlighting its positive impact on learning. Applied in a Biology class, the methodology involved the creation of models, stimulating the understanding of cellular concepts and promoting interaction among students. The results indicate that, despite challenges such as lack of experience and the complexity in creating the models, the strategy enhances content assimilation. Furthermore, student interaction reinforces collaborative learning. Even without a conventional laboratory, the approach has proven effective in overcoming this limitation. In conclusion, the use of models is a valuable pedagogical tool, providing a practical and enriching experience that contributes significantly to scientific education.

KEYWORDS: Pedagogical strategies; Learning; Cytology.

[1] English version by Leonardo Silva de Sousa. *E-mail*: leonardocamilo.itz@gmail.com.

[2] Master in Agronomy – Soil and Water Management (UFPI). State Institute of Education, Science, and Technology of Maranhão (IEMA) – IP Amarante do Maranhão, Amarante do Maranhão, Maranhão, Brazil.Orcid: https://orcid.org/0000-0002-2797-5022. *E-mail*: proftalytacarine@gmail.com.
[3] Ph.D. in Chemistry (UNESP). Associate Professor IV at the State University of the Tocantina Region of Maranhão (UEMASUL). Orcid: https://orcid.org/0000-0001-9421-0524. *E-mail:* jzinid@hotmail.com.

Utilização de maquetes na prática pedagógica para o ensino de biologia celular

RESUMO

A utilização de maquetes no ensino de Biologia oferece uma abordagem prática para compreender as estruturas celulares, promovendo uma visão abrangente da diversidade celular. Este estudo investiga os benefícios e desafios dessa estratégia, destacando seu impacto positivo na aprendizagem. Aplicada em uma turma de Biologia, a metodologia envolveu a construção de maquetes, estimulando a compreensão dos conceitos celulares e promovendo interação entre os alunos. Os resultados indicam que, apesar dos desafios, como a falta de experiência e a complexidade na criação das maquetes, a estratégia favorece a assimilação do conteúdo. Além disso, a interação entre os estudantes reforça o aprendizado colaborativo. Mesmo sem um laboratório convencional, a abordagem mostrou-se eficaz para suprir essa limitação. Conclui-se que o uso de maquetes é uma ferramenta pedagógica valiosa, proporcionando uma experiência prática e enriquecedora que contribui significativamente para a educação científica.

PALAVRAS-CHAVE: Estratégias pedagógicas; Aprendizagem; Citologia.

Uso de modelos en la práctica pedagógica para la enseñanza de la biología celular.

RESUMEN

El uso de maquetas en la enseñanza de Biología ofrece un enfoque práctico para comprender las estructuras celulares, promoviendo una visión amplia de la diversidad celular. Este estudio investiga los beneficios y desafíos de esta estrategia, destacando su impacto positivo en el aprendizaje. Aplicada en un grupo de Biología, la metodología involucró la construcción de maquetas, estimulando la comprensión de los conceptos celulares y fomentando la interacción entre los estudiantes. Los resultados indican que, a pesar de los desafíos, como la falta de experiencia y la complejidad en la creación de las maquetas, la estrategia favorece la asimilación del contenido. Además, la interacción entre los estudiantes refuerza el aprendizaje

colaborativo. Incluso sin un laboratorio convencional, el enfoque demostró ser eficaz para suplir esta limitación. Se concluye que el uso de maquetas es una herramienta pedagógica valiosa, proporcionando una experiencia práctica y enriquecedora que contribuye significativamente a la educación científica.
PALABRAS CLAVE: Estrategias pedagógicas; Aprendizaje; Citología.

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Introduction

Understanding cell structure and function is extremely important for the study of Biology and is essential for advances in various scientific areas. Teaching complex cell biology concepts can be challenging, especially when trying to promote a meaningful and lasting understanding for students (Bezerra et al. 2022). In this context, pedagogical strategies that encourage active learning and hands-on exploration have proven to be effective in engaging students and improving their understanding of biological phenomena (Souza, 2013).

By building and manipulating the models, students are encouraged to observe the different organelles and cell structures in details, understand their functions and the specific adaptations that allow cells to survive and work in different organisms (Silva et al. 2016). In addition, the inclusive approach, which includes both animal and plant cells, enables a more comprehensive and comparative understanding of the cellular diversity that exists in nature.

There are several studies that prove the effectiveness of using models in teaching cell biology (Silva et al., 2016; Elias, Siqueira & Santos, 2016; Marques, 2018; Santana, 2019). A published study showed that the use of three-dimensional models in teaching cell biology led to a significant improvement in students' understanding of cell processes and subcellular structures (Lazarowwitz & Naim, 2013).

Another study, carried out with 1st year high school students at a private school in the northwestern region of Paraná (Bettio et al. 2020), showed that the models contributed to an increase in students' interest in the subject, as well as promoting better retention of the content learned. These are just a few examples of the scientific support for the effectiveness of models in teaching cell biology.

Currently, models are widely used in educational activities to promote student interaction and stimulate collaborative learning. For example, in cell biology classes, teachers have used three-dimensional models to create learning stations, where students can explore different cell structures and biological processes in a practical and interactive way (Stella & Massabni, 2019; Hell, Mendes & Mancini, 2020). In addition, some educational institutions have promoted projects in which students themselves are challenged to create theirown models, encouraging research, creativity and collaboration between classmates (Assis et al. 2016; De Morais et al. 2017; Gonçalves & Dias, 2022). Another interesting approach is the use of models in problem-solving activities, where students need to apply their practical knowledge to solve questions related to cell biology (Procópio et al. 2019; Valença et al. 2023). These are just some of the current ways in which models are being incorporated into educational activities to promote interaction and collaborative learning among students.

The importance of using complementary technologies, such as interactive applications or virtual reality, to enrich students' learning experience is related to the ability of these tools to provide a more immersive and engaging approach, promoting a deeper understanding of the concepts studied (Silva & Sousa, 2022; Pedra et al. 2024).

In a study published by Elias & Gorla (2020), the positive results in learning through an interdisciplinary approach in the teaching of Cell Biology, using architectural design as a tool, are emphasized. The researchers highlight the effectiveness of this integration, pointing out that the interdisciplinary approach promoted a deeper understanding of

biological concepts, increased student engagement and improved knowledge retention. Additionally, they emphasize the benefits of active methodologies and the importance of connecting different areas of knowledge to enrich the learning process.

In addition, virtual reality has been identified as a promising tool for teaching cell biology, as mentioned by Byukusenge; Nsanganwimana & Tarmo (2022). This study carried out a systematic analysis of 26 articles obtained from databases such as Google Scholar, ERIC and Web of Science to review the effectiveness of virtual laboratories in teaching Biology. These virtual labs have been shown to be effective in improving students' conceptual understanding, their practical skills, as well as motivating them and positively influencing their attitudes towards Biology. So, we recommend their use as a safe and cost-effective approach to engaging students in scientific investigations.

Therefore, the use of these complementary techniques not only enriches the students' learning experience, but also prepares them to deal with the technological demands of current and future society. Teaching Cell Biology is often challenging for students as it involves understanding microscopic structures and abstract intracellular processes (Bezerra et al. 2022; Valença et al. 2023). The use of models can provide a three-dimensional and tangible representation of cells, facilitating the understanding of fundamental concepts (Archela, 2008; Guerra et al., 2020).

This study proposes an innovative approach to teaching cell diversity, through the construction of models representing prokaryotic and eukaryotic cells, both animal and plant. The use of these models as educational tools aims to provide students with a practical and tangible experience, allowing them to explore the structure and distinctive features of these cell types in a concrete way (Silva & Morbeck, 2019).

In this way, this article describes the development and implementation of a teaching strategy centered on the use of mock-ups,

exploring the benefits obtained and the challenges faced during the process. As well as providing preliminary evidence of the positive impact of this approach on student learning, it reflects on its implications for teaching cell biology and promoting more effective and meaningful science education.

Methodologies

The methodology used in this study involved a practical and participatory approach, of the experience report type (Calvacante & Lima, 2012; Duarte & Santos 2022), carried out in a technical laboratory course class, during Biology lessons. Initially, the students were subjected to an online draw, in which they were assigned to one of the cell categories: prokaryote or eukaryote, animal or plant. This procedure aimed to ensure an equitable distribution among the participants and to promote a diversity of approaches in the construction of the models.

After the draw, the students were given a set amount of time to make their models. During this time, they were encouraged to research and understand the structural characteristics of the designated cells, using resources such as textbooks, scientific articles and reliable online materials.

Once the models had been completed, the students again had to draw lots, this time to determine the order in which their models would be presentedand explained. This process was fundamental in promoting the active participation of all the students and providing a variety of perspectives in the presentation of the content.

In the presentation stage, the students were instructed to explain in detail the components of the cells represented in their models, highlighting their morphological and functional characteristics. To do this, they were encouraged to use accessible language and visual aids, such as diagrams and schematics, to make it easier for their classmates to understand.

Finally, the presentations were followed by a group discussion, in which the students were able to exchange ideas, clarify doubts and consolidate their understanding of the differences between prokaryote and eukaryote cells, as well as their variations in the animal and plant kingdoms.

This methodology provided a practical and collaborative learning experience, allowing students to explore the concepts studied in class in a dynamic and interactive way. It also encouraged the development of skills such as research and communication, which are fundamental to their academic and professional training.

Results and Discussion

The integration of pedagogical tools in the teaching of cytology/cell biology provides essential practical support for the effective organization of the teaching and learning dynamic (Pereira et al., 2020). The students created representative models of prokaryotic and eukaryotic cells (both animal and plant), using a variety of techniques and resources (Figure 1).

This activity was based on the theory of Sepel & Loreto (2007), which argues that didactic models have significant pedagogical potential, presenting themselves as stimulating and engaging challenges that can be developed with low-cost materials.

During the model-making process, students faced challenges in constructing the product due to their lack of experience with manual work and the complexity of the scientific concepts involved, requiring a detailed understanding of the structural characteristics of the represented cells.

Despite the barriers encountered, the students demonstrated perseverance and a willingness to overcome these obstacles, seeking additional support from peers and teachers when necessary. These

temporary difficulties in assembling the models not only highlighted the challenging nature of the project but also provided valuable opportunities for the development of problem-solving skills and teamwork.

FIGURE 1: Models of prokaryotic and eukaryotic cells (animal and plant) made by the students.

Source: Author, 2024.

The use of models as a didactic-pedagogical resource proved to be significant in promoting a better understanding of the content by students. In general, it played a decisive role in overcoming learning difficulties by providing a clearer visualization of cellular structures, which were previously accessible only through books and handouts. Student reports were unanimous in highlighting the meaningful learning experience provided by this activity.

This contribution of models to learning was also observed in the study by Gallão et al. (2017), in which a model representing the protein synthesis process was developed. The results obtained in both groups demonstrated that the visual and tactile perception of protein composition and its synthesis process was facilitated through this approach.

Bezerra et al. (2022) conducted a study in a public state school in Parintins, AM, with four first-year high school classes. The objective was to promote knowledge of cellular components and the differences between animal and plant cells, as well as their functions, through the creation of cell models. The results showed that direct contact with tangible objects facilitates the learning process.

The use of didactic models in teaching Biology concepts is crucial to placing students at the center of the learning process (França, 2019). It is essential to encourage the use of these models in various educational institutions as a complement to theoretical content, thereby facilitating the integration between theory and practice (Dantas et al., 2016).

By incorporating models into cell biology teaching, educators can create more dynamic and engaging learning environments that stimulate students' curiosity and prepare them to face the challenges of contemporary science. Thus, models not only aid in knowledge transmission but also contribute to the development of individuals who are more critical, creative, and capable of understanding and addressing the complex scientific problems of today.

Conclusion

Based on the above, it was observed that the use of models in the teaching of Biology/Cytology significantly contributed to the understanding of concepts, structures, and functions of different cells. However, despite the benefits observed, several obstacles to adopting this practice remain evident,

such as the lack of experience with manual work and the complexity of the scientific concepts involved.

Throughout the development of this research, it was possible to overcome these challenges, as reflected in the interaction observed among students and the satisfactory participation of the entire class. Given the presented evidence, it is clear that the absence of a laboratory does not hinder effective teaching, as various pedagogical strategies can effectively bridge this gap.

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