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Integration between theory and practice in teaching ecology in the undergraduate course in biological sciences

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ABSTRACT

The role of Ecology education is to foster the development of citizens in order to achieve a broader understanding of the natural world and its interaction with humanity. This paper presents a report from a didactic experience that occurred during the Ecology course taught to students of the Biological Sciences course at the Federal University of Mato Grosso do Sul, Brazil. The experience involved the combination of theoretical activities in the classroom and practical activities (field classes) at a research field station located in the municipality of Corumbá, Brazil, within the Pantanal biome. The theoretical and practical activities aimed to help students understand the various concepts addressed in Ecology, in a participatory and contextualized way, with the students themselves conducting research in Ecology. The combination of theoretical and practical activities contributed to the students' learning, especially in the possibility of observing how Science is constructed. Through this activity, students developed socio-emotional skills and abilities that are fundamental for interaction and task completion, such as expanding the knowledge they already had, the scientific, critical and creative thinking, communication and argumentation.
KEYWORDS: Practical lessons; Science teaching; Didactic strategies.

Integração entre teoria e prática no ensino de ecologia no curso de graduação em ciências biológicas

RESUMO

O Ensino de Ecologia tem como papel propiciar a formação de um cidadão que tenha compreensão mais ampla sobre o mundo natural e sua interação com a humanidade. Neste trabalho, é apresentado um relato de experiência ocorrido durante a disciplina de Ecologia ministrada para acadêmicos do curso de Ciências Biológicas da Universidade Federal de Mato Grosso do Sul. A experiência envolveu a união de atividades teóricas em sala de aula e prática (aula de campo) em uma base de estudos localizada no município de Corumbá – MS, dentro do bioma Pantanal. As atividades teóricas e práticas tiveram como objetivo colaborar com o entendimento dos acadêmicos em torno dos diversos conceitos abordados na Ecologia, de uma maneira participativa e contextualizada, com os próprios acadêmicos realizando pesquisas na área da Ecologia. A união das atividades teóricas e prática contribuiu para o aprendizado dos alunos. Sobretudo na possibilidade de observar como a Ciência é construída. Por meio desta atividade, os alunos desenvolveram competências e habilidades socioemocionais fundamentais para a interação e realização das tarefas, como ampliação do conhecimento, pensamento científico, crítico e criativo, comunicação e argumentação.
PALAVRAS-CHAVE: Aula prática; Ensino de ciências; Estratégias didáticas.

INTRODUÇÃO

In Brazil, the environment is present in the Federal Constitution of 1988, in article 225, section VI, where it is determined that:

> Everyone has the right to an ecologically balanced environment, a common good for the people and essential to a healthy quality of life, and it is the duty of the public authorities and the community to defend and preserve it for present and future generations. [our translation] (Brasil, 1988).

In addition to the 1981 Constitution, the Novo Código Florestal Brasileiro (Brazil, 2012) – New Brazilian Forest Code – highlights, for the first time, in section II of article 1, the importance of the role of forests in human well-being: "strategic function of agricultural activity and the role of forests and other forms of native vegetation in sustainability, economic growth, and improving the quality of life of the Brazilian population (...)" [our translation] (section II, article 1, Brazil, 2012).

Due to the recognition of the importance of debates on environmental conservation and preservation, Ecology permeates discussions that address the future of the Earth. There is growing concern about the impacts that humanity is generating on nature through its daily actions (Tol, 2002; Kormondy & Brown, 2013). Qualifying this debate involves reflecting on and deepening knowledge regarding these concepts. Given the diversity and severity of environmental problems, a central concern is to question the adopted economic development models, production and consumption patterns, and, ultimately, the relationships between society and nature (Peterson et al., 2005; Rodrigues, 2018).

Ecology is the scientific study of the distribution and the abundance of organisms and the interactions that determine the distribution and the abundance. According to Begon, Townsend and Harper (2018), the analysis of these factors commonly takes into account three points: ecological phenomena occur at a variety of scales (temporal, physical and biological); ecological evidence comes from a variety of sources; and, Ecology relies on truly scientific evidence and statistical application. What makes Ecology a rigorous science is that it is based on conclusions, which are the results of carefully planned investigations with well-considered sampling framework, and on conclusions to which a level of statistical confidence can be attached (Gotelli, 2010; Ricklefs, 2010).

The main applications of ecological knowledge include topics such as pollution, sustainability and conservation (Townsend; Begon & Harper, 2009). The role of teaching Ecology is to provide the education of citizens who have a broader understanding of the natural world and the effects of their actions on the conservation of natural systems and, consequently, on ensuring their quality of life. Furthermore, it enables individuals to be able to make decisions based on the knowledge of the conservation and management of natural resources (Seniciato & Cavassan, 2004; Jordan et al., 2009).

According to Lago and Pádua (1985), several "Ecologies" constitute the conceptual field of Ecology. According to Manzochi (1994), these "Ecologies" are taught throughout the schooling process. The student is responsible for deciphering each of these facets, and the teacher is responsible for knowing them so that the pedagogical objectives involved are clear. The various Ecologies are: natural ecology, human ecology, conservationism, and ecologism (Lago & Pádua, 1985). Natural ecology is the one that includes the study of processes and patterns

in ecosystems, communities, populations, and individuals. Human ecology has as its object of study the relationship between human beings and Nature. Conservationism involves strategies in favor of the conservation and preservation of natural resources. Finally, ecologism is a political project of social transformation, and its central idea is the resolution of the environmental crisis.

The lack of study regarding these different ecological approaches leads to learning disadvantages. Lacreu (1998) argues that an approach based solely on developing behavior, without offering knowledge, becomes dogmatic; conversely, an approach based solely on transmitting knowledge becomes scientific. This phenomenon can be observed in the statements of elementary school students about ecological concepts, which show that most of them conceptualize Ecology as the preservation and conservation of natural resources (Contin & Motokane, 2012). Therefore, the understanding of the processes related to the use and conservation of natural resources requires special attention in the teaching of Ecology (Berzal & Barberá, 1993).

In undergraduate courses in Biological Sciences, Ecology is usually addressed in a class in which the concepts of Ecology are presented, as well as the model by which it operates, taking into account the complexity of the relationships between living beings and the environment. These concepts can be found in academic books on Ecology, such as: Ricklefs (2010), Begon; Townsend and Harper (2007), Krebs (2006), Odum and Barrett (2015). In the development of the subject during classes in the undergraduate course, it is shown the importance of Ecology for understanding the complex relationships between human beings and between them and other beings in the ecosystem. Such knowledge can contribute to the protection of natural environments and, thus, of humankind (Medeiros & Bellini, 2004; Scarano & Oliveira, 2005).

Presenting the complexity of Ecology is not an easy task for teachers. Teaching expositive classes with planned program content can be an ineffective practice. During an expositive class, a large volume of content is presented by teachers. Although these classes are accurate, they do not fully satisfy the students' possibility of experiencing a class beyond the classroom walls. One alternative adopted has been the use of practical classes in natural environments, the so-called field classes. Several researchers have presented field classes as an important resource in the teaching and learning process of Science and Biology classes, since these classes contribute to the involvement, motivation and understanding of the content covered (Seniciato & Cavassan, 2004; Silva; Grandi & Motokane, 2012; Mello & Mendes, 2020; Lima et al., 2023; Silva & Santos, 2023).

The objectives of these classes usually include training in scientific research activities, ranging from research planning to oral and written scientific communication and knowledge of the biology of organisms and the environmental characteristics of the region (Corrêa et al., 2004). However, despite the positive aspects of this class model, the use of different learning methodologies in Ecology, which take into account the use of spaces that go beyond the classroom, is still not very widespread (Favoretti et al., 2020). Difficulties include lack of transportation, materials, compatible schedules, or even lack of interest from the teacher (Silva et al., 2014).

In these field classes, students have direct contact with the object of study and they are encouraged to observe the environment in which they are inserted, within a perspective of cause-and-effect relationships between the environment and living beings. Field classes are an important teaching resource that can help in building knowledge and facilitating the teaching-learning process in Ecology. This activity is an important tool in the exploration of various ecosystems, allowing an intimate knowledge of the relationships that occur in the natural environment (Iveiro & Diniz, 2009; Seniciato & Cavassan, 2009; Silva et al., 2014).

Practical classes held in a natural environment provide a confrontation between theory and practice. They also contribute to the student's involvement and interaction with real situations, stimulating their curiosity about the subject (Viveiro & Diniz, 2009). Furthermore, when they are developed in a more active way, so that the student can make observations, collect data and share their results, they allow the student to be the protagonist of their own learning and they favor the formulation of more complex hypotheses about the phenomena studied.

In traditional lectures, students usually act as listeners, so that the information presented by teachers may be memorized, but it ends up being forgotten in a short period of time. Furthermore, in this system, the concepts learned end up having no relation to the students' daily lives, which makes the knowledge abstract. With the development of experimental activities, the class becomes diversified, with more dynamic and enjoyable teaching. By observing and manipulating different materials, students have the opportunity to build their knowledge in a playful and more meaningful way (Bizarro et al., 2014).

Classes that involve observation, manipulation and data collection activities become a teaching option that contributes to better learning, since their methods and experiments help in understanding the content being applied. In higher education, a strong classification between lectures (theoretical lessons) and practical classes is observed in the organization of the subjects, regarding the content and the methods (Morais, 2002). In the Biological Sciences course, there are two main models of lessons: theoretical classes (lectures), in the classroom, and practical classes, in laboratories and in a variety of environments (outdoors), such as field classes and visits to exhibitions (museums, aquariums, zoos, vivariums, etc.) (Castanho, 2002).

This paper presents a report of an experience that occurred during the Ecology course taught to fourth-year Biological Sciences undergraduate students at the Federal University of Mato Grosso do Sul (UFMS). The experience involved the conjunction of theoretical and practical activities, which aimed to collaborate with the students' understanding of the various concepts addressed in Ecology, in a participatory and contextualized way, with the students themselves conducting research in the area of Ecology.

METHODOLOGY

The study was developed in October and November 2019. Twenty-five 4th-year Biological Sciences students from the Federal University of Mato Grosso do Sul, located in the municipality of Aquidauana (state of Mato Grosso do Sul, Brazil), participated in the activities. The activities were developed in two stages: in the first, theoretical classes (lectures) were held (4 classes lasting 4 hours) and in the second stage, practical classes (4 classes lasting 4 hours).

In the classes, concepts related to the field of Ecology, the importance of scientific rigor and the use of the Scientific Method in Ecology studies were discussed (Table 1). In these classes, the following theoretical frameworks were used: Begon; Towsend; Harper., (2007), Towsend; Begon; Harper., (2009), Ricklefs (2010) and Gotelli and Elison (2010). In order to observe the knowledge of the undergraduate students about Ecology, in the first class they were asked: What is Ecology? What does Ecology study?

Table 1

Teaching sequence of theoretical classes in the Ecology discipline.

Lectures	Syllabus
Lecture 01	What is Ecology? Ecology and Scientific Rigor Applied Ecology (Sustainability, Pollution and Conservation Biology).
Lecture 02	Organisms and their environments. Conditions and resources that affect the distribution of living things.
Lecture 03	Population and community dynamics. The effect of competition on community organization.
Lecture 04	Flow of matter and energy in ecosystems. Role of primary producers and decomposers in ecosystem dynamics.

Source: Prepared by the authors (2022).

In the second stage of the study, the students participated in practical classes, which took place at the Base de Estudos do Pantanal (BEP), a research field station belonging to the Federal University of Mato Grosso do Sul. The BEP is located on the right bank of the Miranda River, in the region known as Passo do Lontra (between the pantanais of Miranda and Abobral). The BEP area corresponds to 21.5 hectares and is located in the municipality of Corumbá, state of Mato Grosso do Sul, Brazil. The Pantanal is known for being formed by a mosaic of environments, where the flood pulse (dry and wet periods) is the main structuring force of the communities (Junk et al., 1999). Annual floods inundate a vast area for months. A small altitudinal gradient of a few meters allows higher areas to not be flooded, remaining as islands in the flooded plain (Bordignon et al., 2007). The Pantanal is recognized worldwide for the abundance of its fauna (Mittermeier et al., 1990; Harris et al., 2005) and is considered a Biosphere Reserve and Natural Heritage of Humanity by UNESCO (Brazil, 2018).

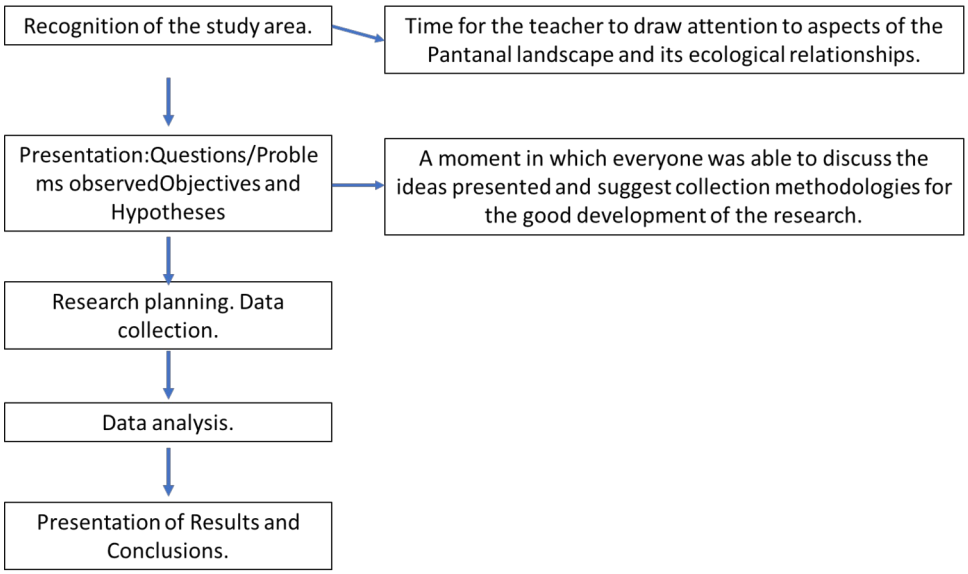
The activities were developed during 4 classes of 4 hours each. In the first class, the application of the hypothetical-deductive scientific method was discussed as a tool to answer questions/doubts that could arise during the exploration of the area (Popper, 1993; Magnusson et al., 2015). Next, the students

were introduced to the study area, drawing attention to the characteristics of its fauna and flora and the adaptations of living beings to variations in drought and flooding. The exploration involved a walk along a trail on the banks of the Miranda River and observations around the BEP.

In the second class, data was collected for the research proposed by the students. The third class involved analysis of the collected data and in the fourth class the research results were presented orally along with a presentation of a panel made by the students during the practical field class (Figure 1).

Figure 1

Sequence developed in practical classes of the Ecology discipline.



Source: Prepared by the authors (2022).

RESULTS AND DISCUSSION

During the first stage of this research, effective participation of the students was observed, who were curious and enthusiastic about the possibility of carrying out a practical activity in the field. The same situation was observed by Rosa et al. (2014), Marques et al. (2019) and Lima et al. (2023). When reporting their activities, these authors highlighted that field practice in Ecology classes represented a facilitating mechanism for understanding content, provided greater interaction between student and teacher and it provided an opportunity to recognize ecosystems characteristic of the region, which were not known by the students.

It is worth noting that, although the town of Aquidauana is located in a transition area between the Cerrado and Pantanal biomes, most of the students who participated in the field class had not yet had contact with the Pantanal biome, that is, they had only had contact with it through books and the media. Thus, in addition to learning concepts and applications of Ecology, the students were able

to observe other characteristics of the place where they live. Knowledge of the aspects involving fauna and flora, ecological processes and the characteristics of a landscape are extremely important for its conservation. One of the ways to disseminate this information, discuss its importance and help in its preservation is to discuss the topic in the learning environment.

Nowadays, with the growing debate on socio-environmental issues, the field of Ecology frequently appears in society's discourses and often with a varied meaning that differs from that applied to its etymology (KATO et al., 2020). In this regard, studying environmental issues becomes important to understand the mechanisms of nature and the anthropic actions related to its use. Increasingly, the educational approach is not limited to the content of textbooks, but it continues in a way that the student begins to relate environmental practices to the exercise of citizenship (Medina & Santos, 2011; Moro et al., 2017).

In other words, when studying environmental issues that involve their municipality, these students have the opportunity to understand their role within the environment, the causes and consequences of environmental changes, and understand how that environment should be used and preserved. As pointed out by Lima et al., (2023), the students' experience in green areas of a given region "helps to establish a relationship of belonging with that environment, as well as promotes an understanding of its function in the socio-environmental context" [our translation] (Lima et al., 2023, p. 10).

When asked *What is Ecology? What does Ecology study?*, all students answered the questions. All the answers were related to the study of the environment [our translation]:

Student A: *It studies the environment.*

Student B: *It studies the distribution of living beings in the environment.*

Student C: *It studies the environment, which helps in its preservation.*

Student D: *It studies ecosystems.*

Student E: *It studies the life of species and ecosystems, which helps in their preservation.*

The answers presented are excessively broad and they reflect very little of what can be developed in research in the area of Ecology. The answers by the students reinforce that the concept of Ecology brought from Elementary School/High School is related to aspects involving the environment and its conservation and preservation. Cherif (1992) pointed out two major barriers to the development of an understanding of what Ecology is. The first comes from the lack of involvement of Ecology researchers with the elementary/high school. As a result, educators in schools lack exchanges with the scientific community. And the second barrier is related to the lack of clarity of the subject in the university itself, in the sense that many professors do not cover topics related to recent advances in the area and trends in research work at the undergraduate level. In other words, they remain restricted to basic content.

Furthermore, much of what the college students think about what Ecology is related to their knowledge from the media (television, newspapers, magazines, etc), which uses the term Ecology to encompass various topics related to the

environment (pollution, lack of water, floods, extinction of plants and animals, among others). Lacreu (1998, p. 128) highlights that:

> [...] the indiscriminate and inappropriate use of "ecological" terms generates their mechanical and unreflective use, which can lead to them remaining at a superficial level, causing the essence of the problem to be lost sight of. It also highlights the discrimination between the science of ecology and environmentalism as an ideological stance, which causes the population to receive the "echoes" of this ideology in a massive way, assuming it dogmatically and unreflectively, an uncritical acceptance of everything that is conveyed in the name of "nature" [our translation] (Lacreu, 1998, p. 128).

This fact demonstrates the importance of studying Ecology involving the search for methods that enable a teaching and learning process in which students can observe the full complexity of this Science. In other words, based on the concepts discussed in class, students observe that part of basic research begins with a set of observations about nature, which in turn, these observations identify and describe a consistent pattern.

Within this context, during the development of the classes reported in this research, the complexity of Ecology was presented to the students. It was made clear that, although Ecology emerged with the purpose of studying the distribution of living beings in environments and the interactions between living beings, Ecology currently presents itself as a systemic thought. In this way, it seeks to understand the complex interaction between living beings, the effect of human beings on these interactions as a modifying agent of the landscape and the global effects of these changes on maintaining humanity's quality of life (Kormonky & Brown, 2002; Maciel et al., 2018).

After the presentation of concepts and discussions on various Ecology topics, the practical class represented the moment in which students were able to observe the natural environment and explore their curiosities/questions about what was happening in that environment. During the walk to recognize the area, the professor drew the attention of students to the natural phenomena that were happening in that landscape, always seeking to bring the concepts discussed in the theoretical classes. For example, during the walk, attention was drawn to the water mark left on the trees after the flooding period in the Pantanal. At that moment, the professor asked: Are the organisms that live in the Pantanal adapted to the cycle of flooding and drought? Is the cycling of nutrients in this area affected by the flooding and drought? And what about the distribution of fish, what happens during the dry and dry periods? How can we answer our questions? How can we apply the Scientific Method?

From these discussions, the professor drew attention to the importance of observation, how to seek answers by applying the scientific method, how to propose and test the hypotheses presented, how to collect and analyze data and, finally, how to present this data to the community. In the second moment, the academics organized themselves into groups and set out to find their own questions/doubts and queries (Sequence presented in the Methodology, Figure 01). At the end of this process, the groups presented their ideas to their colleagues. There was discussion around the ideas, which enabled arrangements and adaptations of the hypotheses presented and the data collection methodology.

The students' different views could be incorporated into the response as alternative explanatory hypotheses, which allowed students to become more

familiar with the concepts discussed in class and the scientific method. The use of short questions to be discussed in small groups is an efficient strategy for involving students in the discussion. Based on the questions, the teacher guides students in the construction of their knowledge and in the search for answers to the questions presented (Schoereder et al., 2012).

At the end of this process, the groups of undergraduate students from the Biological Sciences course carried out work with the following titles [our translation]:

- Research Project 01: Is arthropod diversity higher on flowering or non-flowering branches?

- Research Project 02: Invertebrate diversity in lentic and lotic environments

- Research Project 03: Is the fungi distribution influenced by plant circumference?

- Research Project 04: Comparison of invertebrate richness and abundance in open and closed areas

- Research Project 05: Diversity of arthropods associated with litter distributed at different points along the banks of the Miranda River

Field classes are an important teaching resource that can help build knowledge and facilitate the teaching-learning process in Ecology. Activities like these can help students learn effectively, in which they acquire, interpret and use information to build knowledge, and it also contributes to their motivation in learning (Krasilchik, 2008). This teaching approach assumes that students have autonomy to investigate and experiment, maintaining a leading role in their learning (Berbel, 2011).

Such activities, in addition to arousing students' interest, help introduce basic concepts, develop technical skills, introduce students to the world of scientific research and the search for problem-solving (Nascimento & Coutinho, 2016). In this way, knowledge of research methods is developed; interpretation of research results; knowledge of how scientific knowledge is generated; knowledge of how hypotheses and theories are constructed (Viana et al., 2010; Paiva et al., 2016).

In the proposed activity model, the student constructs his/her doubts and seeks answers. This contributes positively to the processes of developing autonomy. In other words, at the undergraduate level, the Ecology class in the natural environment (outside the classroom) can also provide the basis for learning about the application of the scientific method, which is essential for future researchers and Science teachers (Karlokoski et al., 2018). In this way, it provides the problematization of reality and allows teamwork (Diesel; Marchesan & Martins, 2016). However, the teacher's experience, in terms of content and teaching strategies, is essential for the success of a field practice in Ecology (Marques; Oliveira & Paes, 2019).

As stated by Bastos (2014):

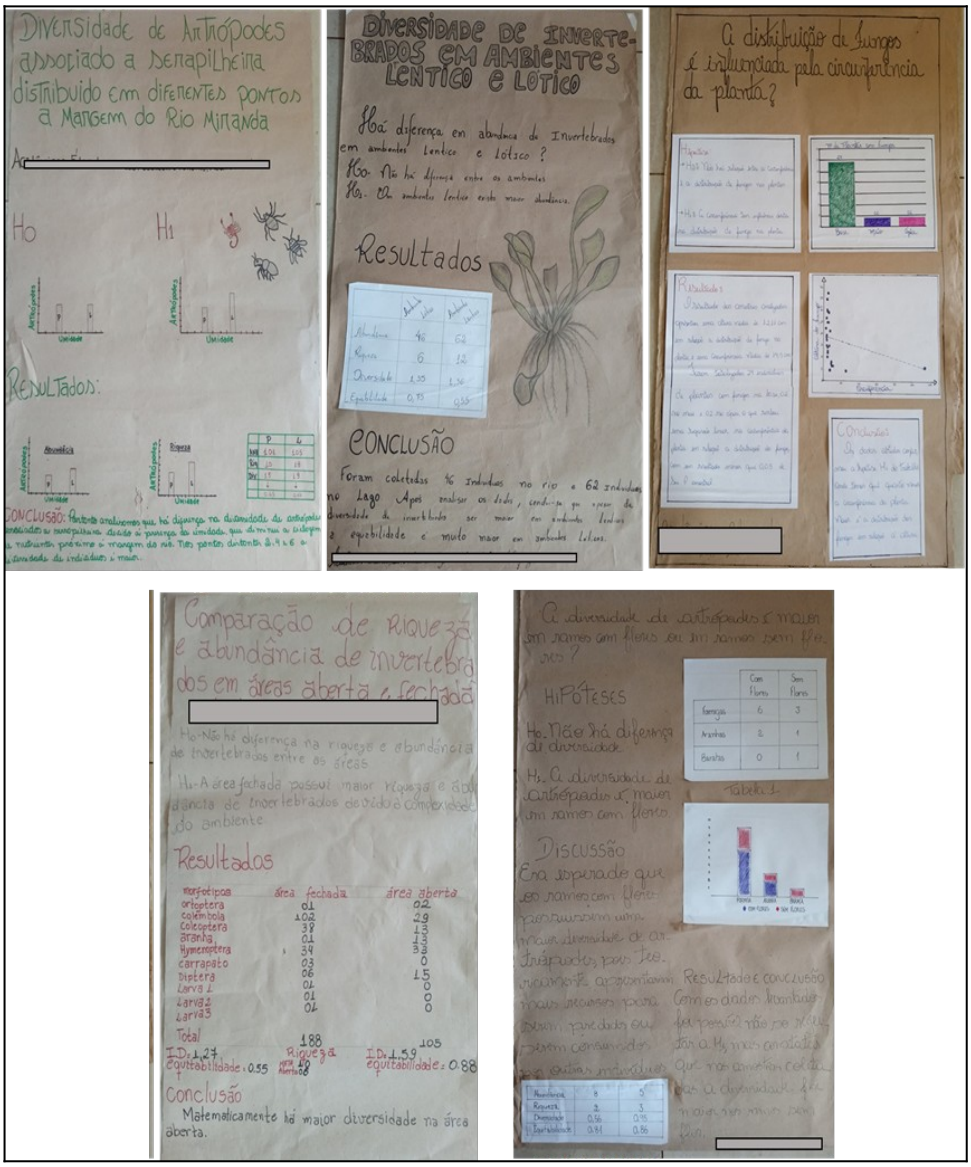
> it is essential that teachers reflect on the importance of renewing their practices in the classroom, not simply “just the action itself”, but developing skills and competencies that allow representation and communication, research and understanding, as well as the sociocultural contextualization of the different contents that make up the Biology subject. One possible way to renew teaching action is the appropriate use of teaching modalities and resources, whether experimental classes, field classes, recreational activities such as

> games, or audiovisual, visual, manual and natural resources. [our translation] (Bastos, 2014, p. 7333).

When presenting the results to their peers, each group explained their problem situation, always seeking to relate it to the Ecology concepts studied in the classroom. For example, the group that presented Research Project 03 “Is the fungi distribution influenced by plant circumference?” revisited the concepts of the effect of area on the abundance and diversity of living beings. In the presentation of Research Project 04 “Comparison of invertebrate richness and abundance in open and closed areas”, the concepts of conditions and resources that regulate the distribution of living beings were revisited. All projects were presented orally and with illustrations made on a panel (Figure 2). Through this activity model, students had the opportunity to practice skills and receive immediate feedback from the teacher. As pointed out by Schroeder, Buch and Longhi (2012), the active participation of the student in the learning process values the individual, stimulates their development and helps to combat the elitist view of knowledge.

Figure 2

Research Project presented by Biological Sciences students in panel format during the practical field class at the Base de Estudos do Pantanal, November 2019, Corumbá-MS.



Source: Prepared by the authors (2022).

Ecology, like all sciences, is a search not for “proven to be true” statements, but for conclusions that we can trust (Towsend; Begon & Harper, 2009). Following this perspective, the students came into contact with several concepts and, in the practical class, were able to test these concepts in an active, meaningful and contextualized way, by understanding the importance of scientific rigor in the development of their projects to obtain results. In this work, it was observed that the integration between theoretical and practical activities contributed to the students’ learning, especially in the possibility of observing how scientific knowledge is constructed. In addition, through this activity, the students had the opportunity to develop socio-emotional skills and abilities that are fundamental for

interaction and task completion, such as knowledge expansion, scientific, critical and creative thinking, communication and argumentation.

There are a variety of teaching approaches, models and methods, each with its own advantages and limitations. This study reported on the experience of integrating theory and practice in teaching Ecology. Obviously, the various teaching strategies adopted by teachers are directly related to their pedagogical and scientific conceptions and their understanding of the educational process. However, success in the teaching profession is related to the correct choices of pedagogical strategies, teaching resources and the way of approaching scientific concepts. The contemporary teacher is responsible for relating the content and strategies that best suit the context of the students for whom the classes are being developed (Gil, 2012; Mazzioni, 2013). Educational success will be favored when the dynamics, resources and strategies chosen by teachers involve the collaborative participation of all those involved, the feeling of belonging to the subject being addressed and the development of a critical sense of why certain content should be learned.

FINAL CONSIDERATIONS

Teaching Ecology is challenging because it deals with a series of complex, current issues that directly affect the lives of all living beings. In addition to understanding concepts, teaching Ecology requires observation and interpretation of the natural environment, allowing for an understanding of the laws that govern ecosystems and the distribution of living beings. From this perspective, the interrelationship between theoretical and practical classes contributes to the development of meaningful learning, which generates an understanding not only of concepts, but also the observation of the construction of these concepts and the laws that guide the functioning and maintenance of ecosystems.

In this report, it was found that the students had the opportunity to develop practical activities in the Pantanal Biome, which helped to awake interest and participation. It is worth noting that, even though this type of travel is not possible, the surroundings of an educational institution can serve as a space for a practical class. Or even, green urban areas such as parks and squares can bring a series of organisms and ecological relationships that make it possible to develop ecology studies.

In addition to observing the natural environment, it is also necessary to encourage the development of activities in which students can collect and analyze data, as well as share the results with their colleagues. Within this model, more than learning Ecology, students learn to develop the scientific method. This scientific literacy contributes to the development of a critical student who is better able to carry out their professional activity after the graduation.

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NOTES

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