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Integration of initial and continuing training of Science teachers: perspectives for outreach curricularization

Integração da formação inicial e continuada de professores de ciências: perspectivas de curricularização da extensão

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ABSTRACT

This study has investigated the possibility of integrating outreach activities into the Biological Sciences course at Federal University of Paraná when the curriculum reform outreach had not been officially implemented. Students from two elective courses took the roles as organizers and instructors in an outreach course focused on the continuing education of Science teachers. One of the course's objectives was to increase the implementation of practical microscopy classes in basic education schools, training teachers to handle microscopes, and presenting methodologies adapted to the school reality. Undergraduate students actively participated in four workshops, contributing to the development of activities, dynamics, and games. The results were positive for all parties involved, highlighting the exchange of knowledge. It is noteworthy that the teachers had the opportunity to update their content knowledge and improve their technical skills in handling microscopes, while the students experienced the initiation into teaching and engaged in the creation of didactic materials. Thus, the feasibility of integrating outreach courses as Outreach Curricular Activities (ACE) II or IV was demonstrated.

Keywords: Outreach curricular activities. Outreach course. Microscopy.

RESUMO

Este trabalho investigou a possibilidade de integrar atividades de extensão ao curso de Ciências Biológicas da Universidade Federal do Paraná, em um momento em que a reformulação curricular para incluir a extensão ainda não havia sido oficialmente implementada. Alunos de duas disciplinas optativas desempenharam papéis de organizadores e ministrantes em um curso de extensão com foco na formação continuada de professores de Ciências. Um dos objetivos do curso de extensão Níveis de organização: das células aos ecossistemas foi ampliar a realização de aulas práticas de microscopia nas escolas de educação básica, capacitando os professores para o manuseio de microscópios, além de apresentar metodologias de ensino adaptadas à realidade escolar. Os estudantes de graduação participaram ativamente de quatro oficinas integrantes do curso, contribuindo com a elaboração de atividades, dinâmicas e jogos. Os resultados foram positivos para todas as partes envolvidas, evidenciando a troca de saberes. Destaca-se que os professores tiveram a oportunidade de atualizar conteúdos e aprimorar-se tecnicamente para o manuseio dos microscópios, enquanto que os estudantes de graduação puderam vivenciar a iniciação à docência e envolver-se na criação de materiais didáticos. Assim, ficou demonstrada a viabilidade da inserção de cursos de extensão como Atividades Curriculares de Extensão (ACE) II ou IV.

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Palavras-chave: Atividades curriculares de extensão. Curso de extensão. Microscopia.

THE ROLE OF CURRICULARIZATION OF UNIVERSITY OUTREACH IN INITIAL TEACHER TRAINING

University outreach presupposes social interaction between the university and other sectors of society. In this process, academic knowledge is shared with the community, which, in turn, teaches about its values, cultures and needs (TIMM; GROENWALD, 2018). This mutual collaboration strengthens ties between the academic environment and society, promoting ongoing and mutually beneficial dialogue. The exchange of knowledge democratizes knowledge and results in scientific, technological and cultural production rooted in reality, establishing a flow of knowledge referenced in everyday life (GADOTTI, 2017; RIBEIRO; MENDES; SILVA, 2018).

The National Education Plan (PNE) 2014-2023 establishes that at least 10% of the curricular credits of undergraduate courses must be dedicated to outreach activities, preferably in areas of great social relevance (BRASIL, 2014). In this way, the participation of outreach in the public education system should be one of the main guidelines for strengthening basic education (FORPROEX, 2001).

In addition to legal support, the curricularization of outreach strengthens the principle of the inseparability of teaching, research, and extension at universities. Outreach activities represent a valuable opportunity for undergraduate students to gain exposure to professional practice, offering them a learning space where they can observe, analyze, act and reflect, contributing significantly to their training as educators (GROENWALD, 2005). By expanding the training space, outreach promotes the development of essential skills and abilities for teaching practice, including lesson planning, content adaptation and use of appropriate methodologies (TIMM; GROENWALD, 2018). In this sense, the inclusion of the outreach in initial teacher training provides practical and immersive experiences that complement theoretical learning, preparing them for the challenges and demands of the professional environment.

THE STUDY OF CELLS IN BASIC EDUCATION AND THE CONTINUING TRAINING OF SCIENCE TEACHERS

Exploring cells and microorganisms, unveiling the “invisible world” through lenses, helps Basic Education students better understand various aspects related to their own health and the environment around them. Using simple techniques involving pieces of plants of scrapings from the tissue lining the human mouth, students can confirm under a microscope that all organisms are composed of cells. They can also see that in a drop of water there can be tiny beings that cannot be seen with the naked eye.

Therefore, promoting practical lessons involving microscopy in schools is essential to stimulate curiosity, critical thinking and scientific inquiry from an early age, preparing students for a broader and more conscious understanding of the world around them.

Based on the interaction provided during nine years of outreach activities in partnership with the Municipal Department of Education, we found that each school of the Municipal Education Network of Curitiba is equipped with at least one optical microscope, and many of them also have boxes of permanent histological slides. However, these resources are underutilized in most schools. One of the main reasons for the scarcity of practical microscopy classes is the insecurity of science teachers in the early years of Elementary School regarding the use of microscopes, due to the lack of specific technical training during their initial training. An additional challenge in implementing microscopy practices in schools is the difficulty of conducting activities for large groups of students with limited equipment. This requires the adoption of complementary activities for studying cells and tissues.

Aiming to fill the gap, the Federal University of Paraná (UFPR) offers continuing education courses and workshops in several areas, including Morphological Sciences and training in the manipulation of various types of microscopes. The emphasis is on approaching the topic through active methodologies, such as practical classes and research-based teaching. The participation of undergraduate students as teachers and monitors of these training activities is essential. While Elementary School teachers often face technical limitations, students in Biological Sciences courses master the use of microscopes from the beginning of their training, becoming able to share their knowledge and skills. In addition, this opportunity allows undergraduates to get close to the reality of the school environment while challenging them to develop educational alternatives such as methods and resources, enriching their training.

POSSIBILITY OF CURRICULARIZATION OF OUTREACH IN THE BIOLOGICAL SCIENCES COURSE

The reformulation of the curriculum of the Biological Sciences course at the Federal University of Paraná (Biological Sciences Sector / Curitiba) was approved only in January 2024. Thus, in this work developed in 2023, we explored the feasibility of including outreach activities in the curriculum, although, at that time, the inclusion had not yet officially taken place.

According to the pedagogical project of the Biological Sciences Course (UFPR, 2023), Outreach Curricular Activities (ACE) can occur in five ways: ACE I – Introductory Course on the Foundations of Outreach, either required or elective; ACE II – Required or elective courses that include, in part or in full, a workload dedicated to participation in community outreach programs or projects; ACE III – Student participation in outreach programs or projects of the institution; ACE IV – Student participation as a member of the organizing team and/or lecturer of courses or events linked to outreach programs or projects of the institution; ACE V –Student participation in programs or projects of other institutions.

For this purpose, students enrolled in two elective courses, Histological Techniques (with 11 students) and Methodologies and Technologies for Teaching Cellular and Structural Biology for Undergraduate Degrees (with 13 students), were engaged in the organization, planning and acting as lecturers of the continuing education course for teachers entitled Levels of Organization: From Cells to Ecosystems, linked to the Microscopy In Practice outreach project, whose activities are aligned with the programs of these courses. Thus, although the curricularization of outreach had not yet been implemented, students enrolled in these courses were integrated into the course team.

The feasibility of introducing ACE II or ACE IV was assessed, considering several aspects: the adequacy of the number of students and participants in relation to the space available for the course; the time required to organize the course, taking into account the schedule of the subjects involved; the relevance of the actions and resources proposed by the students in relation to the training and performance objectives of teachers in the initial years of elementary school; and finally, the contribution of the action to the initial training of undergraduate students.

OUTREACH COURSE LEVELS OF ORGANIZATION: FROM CELLS TO ECOSYSTEMS

The course consisted of five 4-hour workshops, totaling 20 hours of activities. The first four workshops were linked to subjects (TABLE 1). All workshops took place in a laboratory of the Department of Cell Biology at UFPR. The dates were coordinated with the Curitiba Municipal Department of Education to coincide with the availability of elementary school science teachers. All 20 available places were filled, with the number

of participants in line with the space available for the course, also taking into account the presence of undergraduate students in the same space

Table 1 – Outreach Course Workshops Levels Of Organization: From Cells To Ecosystems and their connection with the subject taught in the Biological Sciences Degree course

Month	**Workshop**	**Subject**
April	Microscopy in Practice	Histological Techniques
May	Cell: the basic unit of living beings	Methodologies and technologies for teaching cellular and structural biology for undergraduate students
May	Human being: from cell to system	Histological Techniques
June	Life cycles	Methodologies and technologies for teaching cellular and structural biology for undergraduate students
June	Food chains	Not linked to any subject

Source: Own work (2024).

The course schedule coincided with the period relative to the semester in which the subjects were offered. The students were enrolled in the University Outreach System as members of the course team. Part of the program for each subject was reserved for planning, preparing teaching materials, and conducting workshops.

In the workshop Microscopy in Practice, a variety of optical instruments were presented. From a simple sphere with water to more complex equipment, including handheld magnifying glasses, phonoscopes (portable microscopes connected to smartphones), digital microscopes (with USB connected to computers) (IMAGE 1A), stereomicroscopes, and conventional optical microscopes. Undergraduate students conducted demonstrations of the microscope parts and instructed teachers on how to use them (IMAGE 1B). The participants learned step by step of focusing, observed a permanent histological slide, and also prepared two fresh preparations: an onion cataphyll and a leaf of the plant Egeria densa. At the end, they were able to take a kit with three slides to their respective schools. (IMAGE 1C).

IMAGE 1 – Workshop *Microscopy in Practice*

Source: Own work (2023).

In the workshop Cell: the basic unit of living beings, participants observed water samples collected from lakes in city parks through microscopes. Next, they participated in an activity to understand the size of cells, using the online platform Scale Of The Universe (IMAGE 2A); conducted and experiment to explore the relationship between cell surface area and volume; an investigative activity with microscopes, called O Enigma das Células (The Enigma Of Cells); and, finally, an educational game entitled A Fantástica Fábrica de Proteínas (The Fantastic Protein Factory), which illustrates the role of cellular organelles (IMAGE 2B).

Image 2 – Workshop *Cell: the basic unit of living beings*

Source: Own work (2023).

The levels of biological organization were explored in the workshop Human being: from cell to system. Undergraduate students organized a treasure hunt (System hunt) in which participants explored anatomical models of the human body in search of clues that would lead them to discover the systems, organs, tissues, and cells. (IMAGE 3A). They carried out an activity to understand which equipment can be used to observe an organism at different levels, from the atom to the biome in which it is inserted (IMAGE 3B). Furthermore, they dissected a piece of chicken to identify the tissues

macroscopically, then related them to images of histological sections and virtual atlases (IMAGE 3C).

Image 3 – Workshop *Human being: from cell to system*

Source: Own work (2023).

In the fourth workshop, Life Cycles were the main focus. The main advantages and advantages of sexual and asexual reproduction were illustrated through an acitivity involving representations of genetic material using colored EVA foam sheets, which combine in different ways as the “cells” divide. (IMAGE 4A-B). Next, simulations were conducted to show how certain environmental conditions could impact organisms that reproduce in different ways, highlighting the importance of genetic variability. The different types of development were explored, classifying barious animals as oviparous, viviparous and ovoviviparous (IMAGE 4C). Though a practical exercise, the structure of chicken eggs was analyzed (IMAGE 4D). The last activity consisted of an educational board game created by the students representing the life cycle of the Aedes aegypti mosquito (IMAGE 4E). These activities provided a comprehensive understanding of life cycles and reproduction mechanisms in Biology.

Image 4 – Workshop *Life Cycles*

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Source: Own work (2023).

Students in the courses created original educational materials, such as games, practical and investigative activities, for teaching microscopy and morphological sciences, which are available on the website www.cinterative.ufpr.br, in addition to kits of permanent histological slides for use in basic education (TABLE 2).

Table 2 – Main products generated from the actions

Product	**Type**
Qual o tamanho de uma célula? (How big is a cell?)	Investigative acitivity roadmap
Experimento da esponja (Sponge experiment)	Investigative acitivity roadmap
O Enigma das células (The Enigma Of Cells)	Investigative acitivity roadmap
A fantástica fábrica de proteínas (The Fantastic Protein Factory)	Educational game
Caça ao sistema (System hunt)	Investigative acitivity roadmap
Genes, reprodução e catástrofes (Genes, reproduction and catastrophes)	Investigative acitivity roadmap
Vida de mosquito: ciclo do *Aedes aegypti* (Mosquito life*: Aedes aegypti* cycle)	Educational game
Kits de lâminas histológicas permanentes (Permanent histological slide kits)	Teaching material

Source: Own work (2024).

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SOCIAL TRANSFORMATION AND STUDENT TRAINING

The curricularization of outreach transcends a mere normative requirement, offering an opportunity to transform the relationship between undergraduate courses and basic education schools. This promotes meaningful learning experiences for students and members of the school community, establishing innovative partnerships between teacher training programs and schools, contributing to the improvement of teaching degrees (SANTOS; GOUW, 2021).

Continuing education workshops helped bring science teachers in the early years of elementary school closer to practical microscopy activities. The outreach brings academic knowledge to the school community, encouraging teachers to face challenges in creative and innovative ways (TIMM; GROENWALD, 2018). The teachers' involvement in the workshops, their active participation, and the interest they showed in the content and educational resources used underscore the success of the activities offered. The teachers reported a significant increase in their confidence in using the microscopes available in their schools after participating in the training sessions. One of them said: "My school microscope will no longer be in the cabinet. Now, the principal will allow me to use it as I am properly trained." This highlights not only the individual impact, but also points to the potential for social transformation, indicating that microscopy-related activities will become more frequent in schools.

The undergraduate students enrolled in both courses enthusiastically engaged in planning the workshops, developing teaching resources, and explaining the activities during the sessions. After completion, they were asked about the impact of these actions on their training, and some responses can be seen in Table 3. In the following semester, some of these students also got involved in other project initiatives, taking part in the 41st Southern Region University Outreach Seminar (SEURS) in Ponta Grossa - Paraná, where they held a workshop with some activities developed in the courses. The engagement of some students became even more evident, as they began to carry out Scientific Initiation or Final Course Projects for their bachelor's degrees under the guidance of the project and discipline teachers, continuing the work initiated by the outreach actions.

The students' reports (TABLE 3) highlight a series of lessons learned and profound reflections resulting from their participation in the workshops. Each one of them highlighted specific aspects that contributed significantly to their personal and professional development. Some of them emphasized the opportunity to experience different stages of teaching work, from planning activities to carrying them out in the classroom. The interaction with more experienced teachers during the workshops was highlighted as a crucial point, as it provided students with valuable insights into the reality of school life and different teaching approaches, adding a more practical and realistic view of the school environment. They were able to perceive the diversity of views and methodologies, preparing themselves to deal with this variety of perspectives in the exercise of teaching. The experience of presenting and discussing their activities in front of a larger group of people was described as a moment of personal and professional growth.

The direct contact of undergraduates with teaching practices allowed for reflection on the knowledge necessary for teaching. The development of practical and interactive activities allowed them to develop their creativity and capacity for innovation. They found themselves challenged to stop outside their comfort zone and think of less conventional proposals, seeking to make learning more engaging for their future students. This immersion provided a broader understanding of the challenges and responsibilities involved in teaching practice, preparing them to improve the design of teaching activities and contributing to the development of their ability to deal with different situations and people in the classroom.

Table 3 – Students responses regarding the impact of outreach activities on their education

Did the workshops contribute to your training as a future teacher? How?
The workshop allowed me to experience moments and situations related to teaching, not only during the workshop itself, but also beforehand, with the planning, creation, and preparation of materials for the activities that would be carried out. With these initial challenges and the development of the workshop, it was possible to reflect on the production of knowledge as a teacher because sometimes we are more concerned with the content itself, we don't even realize that there is other necessary knowledge that must be used in the classroom. (STUDENT 1).
I believe that the workshop contributed to improving the way I previously conceived an activity to be applied in the classroom. (STUDENT 2).
The workshop contributed positively to my training. I was able to see in practice how to deal with people and how to help cautiously with activities without getting in the way or compromising the final result that was required. In addition, I realized how to act in certain moments, how to explain activities (both by watching my colleagues and the teacher, and by explaining myself), how to perceive a question that was not verbalized, and the most beautiful thing of all and what gave me the most knowledge was understanding that each of the teachers who passed through there has a life story, a way of thinking, and a way of carrying out activities. Seeing this, I concluded that students in a classroom are also like this and that teachers need to understand these different worldviews and approach content with these different perspectives in mind. In this way, my knowledge of how a classroom works has been expanded. (STUDENT 3)
The workshop helped me develop my creativity, as I had to work with my group to design practical and interactive activities on Cells: the basic units of living beings. Furthermore, I believe that, personally, the experience of speaking to a larger group of people helped me train for when I become a teacher. In addition, contact with different professionals who know how schools and classrooms work allowed me to evaluate whether our ideas and activities would work in a school environment, allowing me to evaluate my knowledge in the area of education from the perspective of a future teacher rather than a student. Overall, the experience was very positive and necessary for my development as an education professional, which I will eventually become. (STUDENT 4)
It contributed positively because, once again, interacting with educators who are familiar with the school environment brings a different reality from what I am used to in the academy. As a result, I am better able to put myself in teacher's place (as a future teacher) when teaching in schools. Furthermore, preparing the activities was a positive challenge, because they forced me to step outside my comfort zone and think beyond what we usually encounter in school. In other words, since the goal of the course and workshops was to present these different topics (in this case, Life Cycles) in unconventional ways or in was that differed from what we are used to in biology, I had to draw on my ability to create materials and be creative in designing these projects. Overall, the experience was once again very positive and gave me the ability to take a more teacher-centered approach. (STUDENT 5)

In teacher training, it is essential to recognize outreach as a formative practice, since it enables the construction of new knowledge and experiences. By facilitating interactions between the university and the community, outreach significantly expands its practices and impacts (CASTRO, 2004). A study conducted by Santos (2019) corroborates the observations of the present work, highlighting the importance of

outreach in initial teacher training, especially when integrated into the academic curriculum. According to the author, curricularization allows students to apply theoretical knowledge in practice and strengthens the connection between teaching, outreach and research. The emancipatory approach combines technical skills with a genuine interest in producing more humanized knowledge focused on contemporary issues (SANTOS; GOUW, 2021).

IS IT POSSIBLE TO INCLUDE OUTREACH ACTIVITIES IN THE ACE II AND ACE IV MODALITIES IN THE BIOLOGICAL SCIENCES COURSE?

The reported experience served as a test of the possibilities of implementing outreach in the form of ACE II, since the outreach course is linked to a project. Regarding the location of the activities, we agree that conducting outreach activities within the university environment, eliminating the need for students to travel to other locations, facilitates compliance with the required hours (SANTOS; GOUW, 2021). Regarding time, the period related to the academic semester was adequate for students to plan, discuss, and prepare the necessary materials for each workshop, in addition to participating in theoretical classes and other activities scheduled in the courses. Considering the space available for the course and the number of students and participants, there were no significant difficulties in carrying out the activities, nor was their quality compromised. However, it is important to note that the number of students involved was close to the maximum, which could have become a problem if it had been higher. The courses involved were elective and had 11 to 13 students, and it was necessary to limit the number of teachers enrolled to prevent the classroom from becoming overly crowded.

Thus, it was evident that this format of elective courses with smaller classes was suitable for student participation in outreach activities with the characteristics present in the course offered. However, it is important to consider that in other course formats, with a larger number of students, it may be necessary to adapt strategies and the way students are guided to ensure the success of outreach and teaching activities. As an example, in the context of the required courses of the Biological Sciences course at UFPR, where the number of students per class is generally higher, around 60 students, carrying out activities of this nature with the same efficiency would become unfeasible.

An alternative would be to divide the class, allowing some of the students to participate in each of the workshops.

The students participated in all stages of activities associated with the courses, demonstrating a solid connection between academic teaching and outreach practices. Timm and Groenwald (2018) also verified the engagement of academics in the development of innovative activities during outreach activities. Those enrolled in the Histological Techniques course learned in detail the techniques for preparing slides, enabling them to perform research and histopathological analysis activities while interacting with the school community, verifying the applicability of these techniques in the educational context, and contributing to the development of teaching materials. Students who took the course Methodologies and Technologies for Teaching Cellular and Structural Biology for Undergraduate degrees had the methodological basis in the theoretical classes of the subject, exercised their skills in creating effective teaching materials, and were able to apply them and test them during workshops, reviewing their effectiveness in subsequent classes and thus completing important cycles in the context of their training as future teachers. Following this successful experience, during the curriculum reformulation, this course was replaced by workshops in Morphological Sciences, with a similar syllabus, but with 100% of the course load dedicated to outreach.

The variety of opportunities for students to engage in outreach projects and activities throughout the course allows them to choose areas that interest them, encouraging the spontaneous and effective integration of outreach into the curriculum (LEITE; HELLMANN, 2023). The possibility for students to have contact with professional activities even before internships is very relevant (ARANTES et al., 2023), especially in courses such as Biological Sciences, in which students must choose between a teaching degree or a bachelor's degree after the basic cycle. In other words, outreach can influence the career choice of the students.

We can also consider the reported experience as a way of incorporating outreach into the course as ACE IV, that is, student participation as members of the organizing team and/or teaching courses and events linked to programs or projects, without involvement in disciplines. In this sense, the integration of outreach into the course is completely viable and beneficial, considering the results presented.

FINAL CONSIDERATIONS

The results and reflections from this experience indicate that a viable way to incorporate outreach activities into the undergraduate curriculum in Biological Sciences is through university outreach courses, whether or not they are linked to specific subjects. Aiming to integrate initial and continuing teacher training, these courses should have specific educational objectives, addressing topics relevant to the school community and the academics involved. The action reported also contributed to the production of teaching materials with the potential to improve the teaching and learning process on cells, tissues, and levels of biological organization. The following year, part of the resources developed by the students in this initiative was applied to another training course for science teachers in the final years of elementary school, which was very well received and generated considerable interest. This demonstrates the quality of the materials and methodologies developed, which are easily implementable in schools.

In this context, the curricularization of outreach programs proves to be an effective strategy for strengthening the relationship between theory and practice, preparing future teachers for the real challenges of the classroom and promoting more contextualized and meaningful teaching. At the same time, the actions contributed to the continuing education of teachers in line with contemporary educational needs, encouraging and enabling an increase in the frequency of practical microscopy classes in schools.

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