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Perception of biological sciences graduates on botanical training

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ABSTRACT

Botany teaching in school education faces several challenges, including obstacles in the initial training of teachers. Investigating pre-service teachers' perceptions can improve teaching by emphasizing knowledge related to ecology, environmental issues, and food security. This study aimed to investigate the perceptions of undergraduate students enrolled in an Undergraduate Biology Teaching Degree regarding the inclusion of "Practices as Curricular Components" (PCCs) in required courses with botanical content. Taking a qualitative-quantitative methodology, a case study was conducted through Focus Group interviews and content analysis supported by NVivo software. The results are presented in two themed categories: (1) The inclusion of PCCs in core courses of botanical content; and (2) The pre-service teachers' perspectives on teaching Botany. The study showed that PCCs have been incorporated into Botany-related courses, but the allocated hours should be continuously reassessed, since a separation between course experiences for teaching and non-teaching degree tracks was observed. Participants also highlighted that many instructors are not licensed teachers or have been away from school for extended periods, resulting in a lack of engagement with innovative and diverse teaching methodologies. Consequently, students reported feeling unprepared to transpose university-level botanical content to classroom teaching. The findings broaden the understanding of Botany teaching in early teacher education and suggest continuous actions such as evaluation meetings, teacher training, curricular changes, and ongoing dialogue with program alumni.

KEYWORDS: Science teaching; Teacher training; University education; Curriculum.

Percepção de licenciandos de ciências biológicas sobre a formação botânica

RESUMO

O ensino de botânica na Educação Básica enfrenta desafios, incluindo obstáculos na formação inicial dos professores. Investigar as percepções de licenciandos pode melhorar o ensino, valorizando conhecimentos sobre ecologia, questões ambientais e segurança alimentar. Este estudo buscou investigar a percepção dos estudantes do curso de Licenciatura em Ciências Biológicas sobre a inclusão das Práticas como Componente Curricular nas disciplinas obrigatórias com conteúdo de botânica. Utilizando abordagem quali-quantitativa, foi realizado um estudo de caso com entrevistas em Grupos Focais e análise de conteúdo com o *software* NVivo. Os resultados são apresentados em duas categorias temáticas: 1) A inclusão das Práticas como Componente Curricular (PCCs) nas disciplinas específicas de conteúdos botânicos e 2) A perspectiva do licenciando para ensinar botânica. O estudo demonstrou que foi realizada a inserção das PCCs nas disciplinas com conteúdo de botânica, porém essa carga horária deve ser continuamente avaliada porque se nota uma separação entre os momentos de aula para os licenciandos e para os bacharelandos. Os entrevistados também ressaltaram que muitos professores não são licenciados ou estão fora da escola há muito tempo e acabam por não trabalhar metodologias inovadoras e diversas. Como consequência, sentem-se inseguros em relação à transposição do conteúdo da graduação para a sua prática docente na escola. Os resultados ampliaram o entendimento sobre o ensino de botânica na formação inicial de professores, sugerindo reuniões de avaliação, capacitações para docentes, mudanças curriculares e diálogo com egressos como ações necessárias e contínuas.

PALAVRAS-CHAVE: Ensino de ciências; Formação de professores; Ensino superior; Currículo.

INTRODUCTION

Botany is a field of science that, for much of the 20th century, was largely considered synonymous with wisdom and intellectual elegance. However, it has experienced a significant decline recently, often regarded as a dry and unenjoyable subject for students. This apparent decline is not exclusive to Brazil, being also observed in several other countries around the world. The key causes for this decline include the discrepancy between its applicability and teaching practices, as well as the lack of qualified teachers (Macedo, Katon, Towata & Ursi, 2012).

Towata et al. (2010), when investigating participants in the 2008 extension course *Teaching Botany in Basic Education* about their memories of learning Botany during Basic Education (which includes early childhood, elementary, and secondary education), found that classes in elementary and lower secondary school were perceived as more engaging than those in high school. This result highlights that activities carried out by teachers for younger students were more dynamic and interesting, whereas in high school, classes tended to focus on content memorization, particularly of specific terms, in preparation for university entrance exams (Towata et al., 2010).

Unfortunately, in higher education, the situation does not seem much different. Silva, Guimarães, and Sano (2016) interviewed students from the Biological Science degrees of four universities and found that, although students pointed out the value of motivating classes with more practical experiences and fewer theoretical lessons, when placed in the role of teachers these same students resorted to the comfort of familiar strategies: theoretical lessons followed by practical ones. Silva and Sano (2011) also documented the strong influence of the behavior of undergraduate professors on how the pre-service teacher will adapt ideas and contents in their own practice. The use of pedagogical practices based on the example of their professors occurs similarly with current faculty staff. Other authors have already warned that university professors develop their teaching practices autonomously, based on personal experiences and post-graduate education (Azevedo & Cunha, 2014; Baldi, 2010; Ferreira, 2010; Gil, 2017; Sordi, 2019), including Botany professors (Marchioretto & Moco, 2024).

Botany teaching in universities remains, for the most part, traditional and academic, with professors focusing on repetition and memorization of extensive terminology required for a botanist's professional practice. As a result, there are not many differences in teaching methods between the subjects of both bachelor's and teaching degrees (Marchioretto & Moço, 2024). Thus, teacher training is undervalued, with a lack of connection to the reality of the school curriculum (Silva, Guimarães & Sano, 2020). Macedo et al. (2012) warn that these programs end up producing ill-prepared teachers who are unable to present a didactic transposition of complex topics into teaching practices and are unable to promote adjustments for greater quality. Consequently, the Basic Education teacher brings these difficulties into the classroom, and they may even develop an aversion to the subject, which can lead to a lack of interest among their students. These factors reinforce a vicious cycle that has made Botany teaching tedious (Ursi, Barbosa, Sano & Berchez, 2018).

In order to establish a clear identity for pre-service teacher training programs, the Brazilian National Education Council (Conselho Nacional de Educação – CNE)

set a requirement for 400 hours of Practices as a Curricular Component (Práticas como Componente Curricular - PCCs) in higher education teaching programs (Resolução CNE/CP No. 02, 2002b). These PCC hours must be integrated throughout the course, including pedagogical content in the curriculum from the early terms, not solely concentrated in the final semesters. However, it was only with Resolution CNE/CP No. 02 (2015) that the Biological Sciences program at the Federal University of Rio Grande do Sul (Universidade Federal do Rio Grande do Sul – UFRGS) incorporated PCCs hours into the mandatory biological content courses, including five courses offered by the Botany Department. This curricular change was approved and implemented in the new curriculum, which came into effect in 2018. Resolução CNE/CP No. 02 (2019) maintained the 400 PCC hours and emphasized the integration of theory and practice in both pedagogical and subject-specific components. Research shows that many Biological Sciences Teaching programs still maintain a separation between pedagogical practice and content-specific practice (Almeida & Teixeira, 2023; Barbosa et al., 2014; Giraldi & Nakayama, 2012; Silva & Estevinho, 2021; Tolentino, 2017). However, there has been an increase in curricula that integrate pedagogical practice into biology-field disciplines (Barbosa & Cassiani, 2017; Brito, 2011; Moretto et al., 2025; Oliveira & Gianotto, 2023; Pereira & Mohr, 2013; Tolentino, 2017). Considering the principle that the curriculum is dynamic and should be continually evaluated, this study aims to analyze the impact of including PCCs in the biology content courses of the teaching program. The results may lead to future curricular changes to adjust and improve the course curriculum. This paper seeks to investigate the perception of students in the Undergraduate Biology Teaching Degree program regarding the inclusion of *Práticas como Componente Curricular* in the mandatory Botany content courses.

METHODOLOGY

This research is characterized as a case study, as it aims to understand the phenomenon of Botany teaching from the perspective of its key actors — in this case, the students enrolled in the Undergraduate Biology Teaching Degree program. The study was conducted in 2020 at the Federal University of Rio Grande do Sul, on the Vale campus, in Porto Alegre, RS, Brazil. Due to the COVID-19 pandemic, no in-person research activities were carried out.

The university in question offers annually 70 seats for the bachelor's degree and 30 for the teaching degree in Biological Sciences. Although the programs are distinct, students from both share 34 mandatory courses in core scientific content areas (Biology, Physics, and Chemistry). The curriculum implemented in 2018 spans a minimum of five years and is divided into ten semesters. Within this curriculum, PCCs were incorporated into 27 mandatory subject-specific courses. Among these, five courses include Botany content and involve nine professors from the Department of Botany.

The population of this study consisted of students from the Biology Teaching Degree program who had already completed the mandatory Botany courses. All enrolled students were invited to participate via email sent by the program's coordination office. However, only those who responded to the invitation were

included in the study. In total, 10 students participated, divided into two focus groups of five members each.

The focus group interviews followed a pre-established set of guiding questions (Figure 1). The sessions were moderated by the lead researcher and supported by an assistant researcher, whose role was to help keep the discussion on track and manage time efficiently. The first session lasted one and a half hours, while the second lasted two hours. Each meeting began with the reading and signing of the Informed Consent Form. Upon receiving consent, audio-only recordings of the discussions began.

Data analysis followed a mixed-methods approach (qualitative and quantitative). The qualitative analysis used Thematic Content Analysis (Bardin, 2016) in three stages: (1) pre-analysis, (2) exploration of the material, and (3) treatment of the results, inference, and interpretation. Pre-analysis included organizing the transcriptions in software NVivo 10, version 1.5, and conducting an initial floating reading (*leitura flutuante* by Bardin, 2016) to validate the predefined categories and subcategories. Interviewees were anonymized using alphanumeric codes (e.g., A01, A02) in the order of speech. The professors mentioned by participants were identified as P01, P02, etc., and the courses were labeled as D01, D02, and so on.

During the exploration phase, the transcripts were read thoroughly, taking into account the students' perceptions. This allowed for the identification of emerging subcategories, the definition of thematic recording units, and the categorization (Figure 1). In the final stage, a simple statistical analysis of the frequency of emergence of the registered units (*unidade de registro* by Bardin, 2016) was carried out, followed by interpretation of the results as a whole.

Figure 1

Summary of the Analysis Categories Presenting the Questions Asked in the Interview

Category	Question	Subcategory
Inclusion of PCCs in specific Botany content courses	1. Do the botany courses in the program include practices aimed at training teachers for Basic Education?	1.1 – yes; 1.2 – no.
	2. What challenges do you think you will face when transposing the content learned in the undergraduate courses to classroom teaching?	2.1 – Time to teach the content*; 2.2 – School infrastructure*; 2.3 – Contextualizing the content*; 2.4 – Understanding the content*; 2.5 – Making Botany interesting*; 2.6 – Developing didatic materials*.

Pre-service teachers' perspectives on teaching Botany	3.Would you apply any strategies used by your professor in your undergraduate classes to your future students?	3.1 – yes; 3.2 – no.
	4. Do you feel prepared to teach Botany content in Basic Education during your internships or when you become a teacher?	4.1 - yes; 4.2 - no; 4.3 - uncertainty*

Note: Only the emerging subcategories are identified with *. The others were predefined.

All necessary authorizations for the implementation of the research were obtained, and the project was approved by the Research Ethics Committee, CAAE No. 42463221.6.000.5347.

RESULTS AND DISCUSSION

CATEGORY THE INCLUSION OF PCCs IN THE SPECIFIC BOTANY CONTENT COURSES

Teacher education programs at the higher education level must include pedagogical practice from the start of the program in all curricular components, not just in pedagogical disciplines (Resolução CNE/CP No. 1, 2002a). Therefore, it is crucial to assess whether these practices are integrated into the curriculum and whether they meet the formative expectations of pre-service teachers. In response to Question 1, all 10 (100%) pre-service teachers interviewed identified a designated workload for teacher education in Botany courses, indicating that PCCs are indeed being implemented within the lesson plans of the current course format. This result was positive compared to the study by Barbosa et al. (2013), which found that more than 30% of students and teachers in the Biology Teaching Degree program were unaware of the PCCs in the curriculum.

However, considering that the curriculum should be dynamic and continuously evaluated, the interviewees in this study also converged in their responses pointing out the need for improvements in these practices. Barbosa et al. (2013) found, from interviews with Biology Education faculty, that there was still a greater emphasis on theoretical content and a misguided belief that teacher education should remain tied to didactic-pedagogical subjects. There is a lack of clarity regarding the origins and objectives of PCCs, leading to various approaches to incorporating them into the curriculum (Pereira & Mohr, 2013; Real, 2012).

It was also noted during the interviews that, despite all courses having PCCs, there appears to be a disconnect between the content-specific classes in the area and the classes focused on teacher education in terms of the distribution of hours, as shown in the transcript excerpt from A02:

A02 - [...] it seems like one hour dedicated to the teacher education component, so she [the teacher] would let us enter later to make up for it at the end, and then we would present a paper as if we were teaching, but it felt like it was

only on paper, dedicating a moment to teacher education, so I didn't feel that it contributed to my practice as a teacher, but it did, right?

It is well known that teacher education practices play a key role in shaping teachers and contribute to the development of teaching knowledge. During these practical activities, theoretical grounding and moments of reflection should take place so that this knowledge is fully understood. From this perspective, teaching is a rearrangement of various types of knowledge: personal knowledge, knowledge from school education, theoretical and curricular knowledge, and experiential or practical knowledge. This makes teaching knowledge plural, composite, and heterogeneous (Tardif, 2000). Moretto et al. (2025), when evaluating the material produced by students in biological courses with PCCs, considered it a genuine and reflective pedagogical experience. Likewise, Almeida & Teixeira (2024) believe that PCCs led to a change in the posture of teacher educators, giving a unique identity to the teacher education program, distinguishing it from the bachelor's degree programs. On the other hand, this positive view is not unanimous. Schmitz & Tolentino Neto (2024) identified that some teacher educators still confuse PCCs with laboratory practical classes and assess the activities as if they were indeed practical classes. Specifically in studies on PCCs in Botany courses, Marchioretto and Moço (2024) also recorded a teacher educator who does not adapt their lessons for pre-service teachers. The above-mentioned authors also noted that most teachers make partial adaptations for pre-service teachers, but there is no consideration on the produced pedagogical practice.

Four interviewees commented on the lack of teachers with degrees in education, noting that their classes are mostly taught by professors who hold a bachelor's degree. This may cause them to appear distant or even uninterested in the demands of Basic Education, focusing excessively on their research areas (Mello, 2001; Pachane, 2003). In higher education, there is an overemphasis on the researcher-teacher, who possesses a curriculum rich in scientific production but little or no pedagogical preparation, as their teaching quality is judged based on their academic output. According to Bazzo (2008) and Severino (2013), this situation stems from the way CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) evaluate courses, by valuing research-related activities.

Following the interviews, a question was asked regarding the challenges faced when transferring the content learned in undergraduate courses to be taught in schools (Question 2). For this question, the responses were longer and more varied, so six emerging subcategories were created, and the frequency of occurrence was analyzed to identify the importance of each unit of record (Table 1).

Table 1
Subcategories and frequency of challenges in applying academic content to school teaching

Subcategory	Response Frequency
2.1 – Time to teach the content	2
2.2 – School infraestructure	3
2.3 – Developing didatic materials	2
2.4 – Understanding the content	4
2.5 – Making Botany interesting	8
2.6 – Contextualizing the content	9
TOTAL	**28**

The subcategories 2.1 and 2.2 refer to difficulties imposed by external factors, particularly within the school infrastructure itself. Two participants mentioned that a possible challenge would be organizing the curriculum content in school settings, expressing concern about meeting the institution's lesson plan schedule while still delivering high-quality lessons to students. Another issue raised by interviewees was the precariousness of public schools, especially the lack of resources to support teaching—whether lab-related or any type of tool that could help implement hands-on methods. The following excerpts illustrate these subcategories:

A10 – *"I agree. Some important points were mentioned. One of them is time. Botany is a very dense subject—if you take two or three months, you'd be talking about Botany the whole time, and it still wouldn't be enough. It's an extensive subject."*

A02 – *"I never had a microscopy class in high school. I only encountered it at university. I didn't even know what I was supposed to be seeing in class, so it didn't make sense. I felt like I shouldn't be there—I didn't know what I was looking at. Was it the microscope? The slide? I couldn't tell. So now I think: where I'll work, will there even be a microscope a 'lupa' (referring to a stereomicroscope)?"*

The interviewees explained that their university classes follow a model of theoretical lessons with slide presentations, followed by practical classes in the lab using live plant material. Although they acknowledged this strategy as highly effective for teaching adults and future botanists, they noted a lack of diverse and ludic materials suitable for use with children in elementary school (subcategory 2.3). In this context, they foresee future challenges in creating such materials for their own students. According to Mello (2001), teacher education should aim for a pedagogical organization that supports the teaching and practical competencies aligned with Basic Education guidelines. However, the author notes a reversed symmetry, where future teachers act only as learners during their training.

In this sense, PCCs should offer an opportunity for developing updated and innovative materials. This was reflected in statements such as the following:

A04 – *"I always thought that the Botany classes were well-prepared, with materials to use, but not much variety—mostly images, PowerPoint, microscope, or the real plant. I'm not saying that's bad or unnecessary, but we're limited to those. Maybe when we, as future teachers, get the chance to apply it, we could learn to create alternative models—that would be great."*

The curriculum of the Biological Sciences Teacher Education Program analyzed here includes 12 subjects related to the field of education, covering History, Philosophy, Psychology, and Sociology of Education. Although these mandatory courses are part of teacher training, their content does not explicitly address playful strategies or the development and use of teaching materials. Ludic materials, such as games and models, should be used to support the teaching of abstract concepts to achieve learning goals (Silva et al., 2016; Silva, Santos & Barros, 2018). Fun, enjoyment, and creativity should be allies of teachers in the classroom, as they significantly contribute to human development, learning, and social, personal, and cultural growth, helping with effective communication and socialization.

A solid understanding of subject-specific content was another major concern raised and was placed in subcategory 2.4. Participants often expressed anxiety about truly understanding their field of knowledge to make it accessible to future students, as highlighted in the following quote:

A03: *I feel that after going through the undergraduate course and leaving all these gaps we were talking about earlier, of having only seen content and only received things without understanding, internalizing, truly understanding how that is done in the world, what that has to do with life*.

Silva et al. (2006) stress the importance of critical reflection on scientific content to enable understanding across economic, historical, political, social, and cultural dimensions. Mastery of technical knowledge alone does not guarantee humane development. Encouraging trial and error and problem-solving allows students to reflect on how scientific knowledge is truly produced (Santos et al., 2021). Souza and Sousa (2018) also argue that the traditional lecture-based model should be replaced with more collaborative classroom dynamics between teachers and students. Innovation through active learning methods, where students make decisions and engage actively in the process, has proven successful in increasing student engagement and overcoming encyclopedic, passive teaching models (Ramos & Silva, 2013; Santos et al., 2021; Vasques et al., 2021).

We can clearly observe that subcategories 2.5 and 2.6 had the highest frequency and significance. Both are directly related to botanical content and should be addressed specifically within the context of Botany education. Reflecting on student interest and contextualization in purely pedagogical disciplines would not be the same. There are relevant and specific aspects of Botany teaching that need to be discussed by Botany educators. Some of the students interviewed by Silva et al. (2018) stated that pedagogical courses do not support the teaching of Botany, as they are taught the same way across all degree programs. Santos et al. (2021) warn that if pre-service teachers do not understand the importance of botanical content, such content will be neglected and often discarded in Basic Education. That is why Mello (2001) considers “teacher training a critical point from which it is possible to reverse the overall quality of education” (p. 157). During initial teacher training, a shift must occur from an academic view of teaching to an understanding of science as a human construct (Leite & Magalhães Junior, 2021).

According to Ornelas & Macedo (2020), there is a need for a didactic approach to botanical content in the training of Biology teachers, one that focuses on *how to*

teach Botany (emphasis from the original) in Science and Biology education—content that is contextualized and integrated. Curriculum fragmentation is one of the causes of conceptual distortions in Biology teaching (Ceschim et al., 2020).

Decontextualized Botany teaching is cited as the most frequent cause of students' lack of interest and learning difficulties (Souza et al., 2016; Ursi et al., 2018). However, this issue can be addressed when teachers value students' prior knowledge, helping them to make connections between new content and what they have already internalized (Ursi et al., 2018). Leite and Magalhães Junior (2021) found that among Biology pre-service teachers, there is still a strong social representation of the teacher as the center of the learning process—someone who holds and transmits knowledge.

Many of the interviewees expressed uncertainty about how to make classroom content interesting to their students and how to design engaging activities for them:

A01 – *I think we need to learn how to teach Botany differently from the way we're receiving it. Because, well... you spend four years—or more, right?—in a degree program seeing that content being delivered the same way, by different people, sometimes with a few changes here and there, but always in that same way.*

Due to the lack of visibility regarding the beauty and importance of plant science, Ursi et al. (2018) recommend the development of aesthetic sensitivity as one of the goals of scientific literacy. This dimension involves the integration of reason, imagination, feelings, and emotions, which can lead to transformative values and attitudes.

Other participants developed their arguments based on the Brazil's National Common Curricular Base (*Base Nacional Comum Curricular - BNCC*), expressing concerns about the required interdisciplinarity and how to apply it in the real-life contexts of students.

A02 – *For me, I think... I pay attention to what's motivating me to like something. After P04's class, I understood the importance of a mango or orange tree because of that little moss—how important it is, and that what's on the sidewalk isn't just weed, it's not a useless plant, it's life. That's what makes sense to me, that's the wonderful way I want to teach.*

A06 – *"[...] The second is 'application to reality,' meaning, what is the application of this? If you're going to teach this in school, in theory, you're following the BNCC, and for those starting their teacher training, that's more or less what outlines the basic paths of what must be covered. So how do I apply this? Where does it fit in?"*

CATEGORY THE PERSPECTIVE OF PRE-SERVICE TEACHERS ON TEACHING BOTANY

This thematic category includes the discussion about which teaching strategies experienced during undergraduate studies could be replicated with their future students (Question 3). All interviewees showed alignment with the discourse that could be identified as "yes" (subcategory 3.1, Figure 1). It was noted that all the strategies mentioned aimed at greater student engagement: hands-on

classes, ludic activities, use of didactic models, and pedagogical workshops. All responses converged on impactful and meaningful experiences for teaching, derived from the use of practical activities in the coursework.

A01 – *I don't think you can learn Botany without practice, at least not in my personal experience. If I only look at a book, I might understand it, but if I don't see it... it's like 'Zoo' [Zoology], I think—it becomes very abstract. You can understand it, but it feels far removed from our reality.*

A09 – *[...] there are some little toys in there (a room used in one of the Biology courses) that we played with a few times. The materials are cute, and I'm curious, so I went there and took apart and reassembled one of the toys—it was a model of the Asteraceae flower. It was adorable*.

Two comments pointed to the continued use of traditional teaching methods in Botany classes, raising concerns that this does not contribute to student learning and likely won't be adopted by these future teachers. This can be seen in the following excerpt:

A03 – *I think the approach of teaching Botany just through the organization of clades... I felt, like A01 said, that I didn't learn anything. I took some classes twice and still felt like I hadn't learned. I was just there to fulfill the hours and memorize things to pass the test—I didn't understand what I was doing, it was all just memorized.*

Ursi et al. (2018) warned that Botany content is still often taught through a unidirectional transmission of knowledge (in which the student has a passive role) and requires extensive memorization of nomenclature, disconnected from real-world contexts. On the other hand, students from Biological Sciences programs at four universities reported that they would like more engaging Botany classes in university, but when put in the role of teacher, they tend to fall back on traditional methods (Silva et al., 2016).

This category also includes the interviewed perceptions of their preparation in Botany for professional teaching practice (Question 4). Initially, the interviewees tended to say they felt prepared, but there was a duality in their discourse that was interpreted as uncertainty (subcategory 4.3, Figure 1). They differentiated between theoretical knowledge and didactic skills acquired during the course, expressing confidence in their theoretical knowledge—largely the result of personal effort—while also acknowledging a lack of preparation in pedagogical and teaching skills. This can be seen in the following statements:

A09 – *I think, above all, being a teacher, a professor, is always a challenge. And being a Botany teacher is an even greater challenge. When we get to the classroom, the students aren't very interested, so we have to work harder. So yes, I'm prepared because I know the content. But the way to apply it? I'll have to figure that out.*

A10 – *I have enough to pass on to my students—they understand when I talk about Botany—but I don't know if I have the didactic tools to teach it, so they'll understand. [...] So I never feel ready. I feel like I got the theoretical foundation to know the content, because I worked really hard to understand it, but I don't have enough didactic tools to teach it.*

In this sense, the gap between biological content knowledge and pedagogical knowledge becomes clear. The participants, as future Science and Biology teachers, show that their initial teacher education still falls short in preparing them for teaching practice. This dichotomy was also highlighted by Souza et al. (2016), who argue that the teaching of Botany needs stronger articulation between university learning and the demands of school education. Thus, both pedagogical courses and content-specific courses must share responsibility for preparing future teachers. Having only the pedagogy courses offered by the faculty of education, disconnected from specific content, does not make sense to the future teachers. This aspect was also identified by Silva et al. (2018), who investigated students' perceptions of how pedagogical practice courses contributed to their preparation for teaching Botany. The results were alarming, as many interviewees reported taking these courses only to fulfill degree requirements.

Ursi et al. (2018) further emphasize that initial teacher education in Botany should prioritize the development of Pedagogical Content Knowledge (PCK), which refers to the teacher's ability to connect Botany-specific content with pedagogical approaches, thereby understanding how best to teach botany in various contexts. For this reason, Botany teaching must be effective not only in enabling the student to master the content, but also in helping them mobilize it in order to adapt its presentation to different teaching contexts. In this regard, as highlighted by Prestes and Boff (2020), educators must keep a critical eye on the teaching and learning model adopted by the school, as fragmentation makes the process less efficient. Alonço et al. (2025) found that research on science teacher education increasingly explores interdisciplinary, social, and environmental themes through learning based on active methodologies, aiming to foster a more dynamic, interactive, and contextualized teaching practice. The study by Prestes et al. (2023) points to the potential of connecting Botany content with other areas of knowledge in order to encourage teachers to adopt an interdisciplinary and contextualized approach in Basic Education.

FINAL CONSIDERATIONS

This study showed that the integration of PCCs into courses with Botany content was implemented, and that participants recognized the teachers' efforts to incorporate pedagogical activities. Overall, the inclusion of PCCs in Biology-related courses had a positive impact. However, it was unanimously emphasized that this instructional workload should be continuously assessed by all parties involved and improved in order to fulfill its true goal of supporting pedagogical development. This concern stems from the fact that participants still observed a separation between the instruction provided to the teaching degree students and that offered to those in the bachelor's track. They also pointed out that many instructors are not trained as teachers or have been away from school settings for a long time, often resulting in a lack of use of innovative and diverse teaching methodologies. Two major concerns emerged from the statements of the teaching degree students: making Botany interesting for their future students and being able to contextualize its content in relation to the reality of the school community.

Participants expressed a clear preference for participatory teaching strategies, such as active methodologies and the use of playful materials. On the other hand,

they showed uncertainty about their ability to carry out the pedagogical transposition of academic content into classroom practice in Basic Education.

This study provides important insights for improving the teacher education program. It is worth remembering that improvement is always the result of dialogue: students share their experiences and express difficulties, the course coordinator brings these reflections to the faculty, who then play an active role in the process of change. After all, even if the courses are restructured, merged, or discontinued, the faculty members remain the same—and many of them are responsible not only for delivering the courses but also for their ongoing enhancement. Therefore, regular evaluation meetings, teacher training sessions, curricular revisions, and dialogue with graduates are necessary and continuous initiatives.

NOTES

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