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O ensino de botânica em uma perspectiva da Base Nacional Comum Curricular e da formação inicial de professores

Botany teaching from the perspective of the National Common Curricular Base and initial teacher training

La enseñanza de la botánica desde la perspectiva de la Base Curricular Común Nacional y la formación inicial docente

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RESUMO

A proposta deste estudo é promover uma reflexão sobre a abordagem do ensino de botânica nos currículos dos cursos de licenciatura para a formação inicial de professores de ciências. A pesquisa foi do tipo qualitativa e para a produção dos dados realizou análise documental que utilizou a Base Nacional Comum Curricular (BNCC) e a BNC-Formação como objetos de estudo. Os resultados e a análise foram organizados em temas contemplando a formação inicial de professores de ciências, o ensino de botânica e a interdisciplinaridade. O curso de formação não integra a aprendizagem dos temas específicos de botânica e os saberes pedagógicos. A botânica não compõe o contexto de cada escola e dos interesses dos estudantes, de forma democrática. O docente do ensino superior tem perfil de pesquisador e forma o jovem professor por meio de metodologias de ensino tradicionais, o que não estimula o uso de estratégias inovadoras e criativas. Recomenda-se que os cursos de formação promovam o trabalho colaborativo integrado com a rede de ensino regional. Conclui-se que o modelo atual de ensino de botânica nos cursos de licenciatura, nos quais a organização dos temas sobre as plantas é fragmentada, não atende às exigências específicas da docência.

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Palavras-chave: Ciências da Natureza; Interdisciplinaridade; Letramento científico.

ABSTRACT

The proposal of the work is to reflect on the approach of botany teaching in curricula of initial science teacher training programs. The research employed a qualitative methodology and generated data through documentary analysis, using the National Common Curricular Base (BNCC) and BNC-Training as study objects. Results and analysis were organized into thematic categories encompassing initial science teacher training, botany teaching, and interdisciplinarity. The training program fails to integrate learning of specialized botany topics and pedagogical knowledge. Botany does not reflect the context of each school and the interests of students, in a democratic way. Higher education professors have a researcher profile and train young teachers using traditional teaching methodologies, which fail to encourage the use of innovative and creative strategies. It is recommended that training programs promote collaborative work integrated with the regional education network. This study concludes that the current model of botany teaching in teaching degree programs, in which the organization of content about plants is fragmented, does not meet the specific demands of teaching practice.

Keywords: Natural Sciences; Interdisciplinarity; Scientific Literacy.

RESUMEN

El propósito de este estudio es promover la reflexión sobre el enfoque de la enseñanza de la botánica en los planes de estudio de los cursos de pregrado para la formación inicial de profesores de ciencias. La investigación documental utilizó como objetos de análisis la Base Curricular Común Nacional (BNCC) y el BNC-Formación. Los resultados y análisis se organizaron en temas que abarcan la formación inicial de profesores de ciencias, la enseñanza de la botánica y la interdisciplinariedad. Se concluye que el curso de formación no integra el aprendizaje de contenidos específicos de botánica y conocimientos pedagógicos. La botánica no refleja el contexto de cada escuela y los intereses de los estudiantes, de manera democrática. Los docentes de educación superior tienen un perfil investigador y forman docentes jóvenes utilizando metodologías de enseñanza tradicionales, lo que no fomenta el uso de estrategias innovadoras y creativas. Se recomienda que los cursos de capacitación promuevan el trabajo colaborativo integrado con la red educativa regional. Se concluye que el modelo actual de enseñanza de la botánica en carreras de pregrado, en el que la organización de contenidos sobre plantas está fragmentada, no responde a las competencias didácticas específicas.

Palabras clave: Ciencias Naturales; Interdisciplinariedad; Alfabetización científica.

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Introduction

The National Curriculum Guidelines for Basic Education are perpetually subject to revisions and debates regarding their purpose and orientation. Nevertheless, neither time nor changes in Brazilian legislation have sufficed to address the historical gaps stemming from Brazil's colonial legacy, which has systematically neglected public education to preserve economic elites' privileges. Consequently, the National Common Curricular Base for Basic Education *(Base Nacional Comum Curricular para a Educação Básica* - BNCC*)*, enacted in 2018 (Brazil, 2018a), reflects this pattern. Since its implementation, the BNCC has served as the mandatory regulatory framework for public and private educational institutions, establishing compulsory reference standards for developing school curricula and pedagogical proposals across early childhood, elementary, and secondary education in Brazil.

Teacher training must likewise adapt to this transformation, aligning with the BNCC's outlined general competencies and essential learnings to achieve Integral Education. Accordingly, stemming from the BNCC, Resolution CNE/CP No. 2 of December 20, 2019 established the National Curriculum Guidelines for Initial Teacher Training in Basic Education and instituted the National Common Base for Initial Teacher Training in Basic Education (BNC-Training) (Brazil, 2019b).

Science teacher preparation for upper elementary grades occurs through Teaching Degree Programs in Biological Sciences or Natural Sciences, offered in-person or via distance learning. These programs must design curricula ensuring graduates advance students' scientific literacy. According to the BNCC, this constitutes "[...] the capacity to understand and interpret the world (natural, social, technological), but also to transform it" (Brazil, 2018a, p. 321).

The essential learning outcomes for the Natural Sciences area are organized into three thematic units: Matter and Energy; Life and Evolution; and Earth and Universe. Plant studies for upper elementary grades fall under Life and Evolution, which addresses "[...] the study of issues concerning living beings (including humans), their characteristics and needs [...]" (Brazil, 2018a, p. 326). Multiple studies have

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warned about the progressive erasure and devaluation of botanical content in curricula and, consequently, classroom approaches (Lima, 2022; Prestes; Severo; Moço, 2023).

BNC-Training for initial teacher education: a competency-centered teacher model

The National Curriculum Guidelines for Initial Teacher Training in Basic Education were revised and updated through Opinion CNE/CP No. 22, published on November 7, 2019 (Brazil, 2019a). This opinion served as the foundation for Resolution CNE/CP No. 2 of December 20, 2019 (Brazil, 2019b), which aimed to update Resolution CNE/CP No. 2 of July 1, 2015 (Brazil, 2015) to align with the BNCC, published in 2018. The 2019 Resolution emerged targeting teacher education through the development of professional teaching competencies that qualify educators to implement the ten general competencies of basic education and the essential learning outcomes established in the BNCC (Brazil, 2019b). These essential learning outcomes must be guaranteed to Basic Education students, considering the intellectual, physical, cultural, social, and emotional aspects of their formation, aiming for the full development of individuals from an Integral Education perspective (Brazil, 2019a).

The BNC-Training proposal interlaces initial teacher education with continuing education and career progression through the integration of three fundamental dimensions: knowledge, practice, and engagement. To understand this interdependent, non-hierarchical movement, the following schema is proposed in Figure 1:

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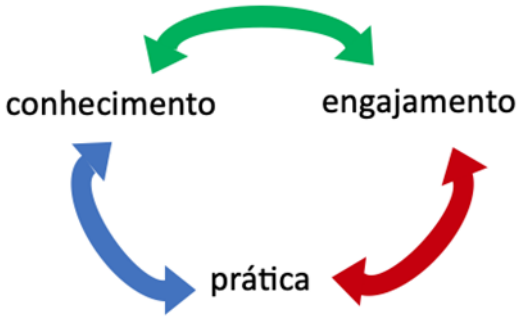
Figure 1 – Movement of specific competencies of teaching professionals



Source: Prepared by the authors (2021) based on Brasil (2019b, p. 49).

In the knowledge dimension, it is understood that teachers must master the BNCC's knowledge objects and know how to teach them, but also know their students and be able to develop teaching strategies according to diverse learning processes. It is essential that teachers recognize the life contexts of the school community in which they are embedded and, furthermore, the structure of the educational systems in which they work (Brazil, 2019b).

In the practice dimension, teachers must plan teaching actions, choose teaching strategies and resources that suit their classrooms, so that it results in effective learning and conditions to assess the learning process (Brazil, 2019b).

The third dimension is engagement, which is based on the need for teachers' commitment to their own professional development, as well as to their students' learning following the principle that all are capable of learning. Teachers must also participate in the elaboration of the school's Pedagogical Project and the construction of democratic values, in addition to being engaged with families and the entire school community (Brazil, 2019b).

From this perspective, seeking to better understand these three dimensions, Table 1 summarizes the specific competencies to which they are linked.

Table 1 – Specific competencies linked to the professional knowledge, practice, and engagement dimensions of BNC-Training.

1.PROFESSIONAL KNOWLEDGE	2. PROFESSIONAL PRACTICE	3. PROFESSIONAL ENGAGEMENT

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1.1. Master the knowledge objects and know how to teach them.	2.1. Plan teaching actions that result in effective learning.	3.1. Commit to one's own professional development.
1.2. Demonstrate knowledge about the students and how they learn.	2.2. Create and know how to manage learning environments.	3.2. Commit to students' learning and put into practice the principle that all are capable of learning.
1.3. Recognize the contexts.	2.3. Assess student development, learning, and teaching.	3.3. Participate in the school's Pedagogical Project and the construction of democratic values.
1.4. Know the structure and governance of educational systems.	2.4. Conduct pedagogical practices of knowledge objects, competencies, and skills.	3.4. Engage professionally with families and the school community.

Source: Brasil (2019b)

BNC-Training defines competency, according to Philippe Perrenoud (apud Brazil, 2018b, p. 42), as "the capacity to mobilize diverse cognitive resources to face a type of situation". Therefore, it is perceived that, to competency, it is attributed a form of "thought schema of complex mental operations (the form) and the contents contained in and composing the action schema" (Brazil, 2018b, p. 42). This concerns know-how, as competency presupposes action and movement.

Given this, according to Resolution CNE/CP 02/2019, the construction of references for teacher education must dialogue with Perrenoud's ten competencies (apud Brazil, 2019b) (knowledge; scientific, critical, and creative thinking; cultural repertoire; communication; digital culture; work and life project; argumentation; self-knowledge and self-care; empathy and cooperation; and responsibility and citizenship), as well as with the BNCC's essential learning outcomes.

Thus, the BNC-Training proposal aims to align teacher education with the BNCC. The unity between these documents is ensured by the competency-based education perspective; this alignment is provided for in articles 5 and 17 of Resolution CNE/CP 02/2017 (Brazil, 2017) and appears strongly in Resolution 02/2019:

> From the perspective of valuing initial and continuing teacher education, the norms, curricula of courses and programs designated for them must align with the BNCC, under the terms of § 8 of art. 61 of the Law of Directives and Bases of National Education (*Lei de Diretrizes e Bases da Educação Nacional* - LDB), and must be implemented within two years from the BNCC's

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> publication, according to art. 11 of Law No. 13.415/2017 (Brazil, 2019b, p. 11).[1]

In this context, it is relevant to provide a brief history of the BNCC, highlighting that this debate began in 1988 with the Federal Constitution, which establishes a common national curricular base in which minimum content for elementary education must be established, aiming to ensure a nationally common basic education (Brazil, 2022).

Subsequently, in 1996, the LDB was approved, regulating a common national base for Basic Education. Between 1997 and 2000, the National Curriculum Parameters (*Parâmetros Curriculares Nacionais* - PCN) were published. The year 2010 brought significant advances, beginning with the National Education Conference (*Conferência Nacional de Educação* - CONAE), in which numerous researchers defended the necessity of a common national curricular base as part of a National Education Plan (Brazil, 2022).

In 2014, through Law No. 13.005, the National Education Plan (*Plano Nacional de Educação* - PNE) was regulated, addressing the BNCC. That same year, the 2nd CONAE debated the mobilization process for the BNCC. In 2015, the First Interinstitutional Seminar for the elaboration of the BNCC took place and, in the same year, the first version of the BNCC was made available, promoting mobilization of schools throughout Brazil for discussion of the preliminary document (Brazil, 2022).

The document's second version was released in 2016, when state seminars were organized with teachers, administrators, and specialists to debate the document. In April 2017, the Ministry of Education (*Ministério da Educação* - MEC) delivered the final version of the BNCC to the National Education Council (*Conselho Nacional de*

[1]Original: "*Na perspectiva de valorização e da sua formação inicial e continuada, as normas, os currículos dos cursos e programas a eles destinados devem adequar-se à BNCC, nos termos do § 8º do art. 61 da LDB, devendo ser implementados no prazo de dois anos, contados da publicação da BNCC, de acordo com o art. 11 da Lei n. 13.415/2017*" (Brasil, 2019b, p. 11).

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Educação - CNE) and, on December 20, 2017, the BNCC was approved, being updated in 2018 with the insertion of the high school stage into the document.

This article aims to promote reflection on the approach to botany teaching in curricula of teaching degree programs for initial science teacher education for upper elementary grades. The BNCC and BNC-Training documents were the objects of analysis.

Methodology

This research is characterized by a qualitative approach, focusing on documentary analysis for producing results. In this regard, Bogdan and Biklen (1994, p. 48) state that "Qualitative research is descriptive. The data collected are in the form of words or images and not numbers."

Regarding documentary analysis, according to Lakatos and Marconi (2017), it consists of data collection from primary sources, which may include written or non-written documents present in public, private, institutional, or household archives, or even in statistical databases. In this work, the primary sources were: the BNCC (Brazil, 2018a) and BNC-Training (Brazil, 2019b).

For Gil (2019), this type of research is especially relevant when the investigated problem requires gathering data dispersed across different locations. In the present study, to ensure research validity and scientific rigor, documentary research followed a structured analysis protocol involving the following stages: (1) obtaining original primary source documents from Brazilian government websites and identifying other relevant documents for understanding the research context, such as opinions, legislation, curriculum guidelines, and educational policies; (2) in-depth reading of texts for extracting pertinent data; (3) categorizing data according to the study's central thematic axes of initial science teacher education and botany teaching; and (4) critical analysis of themes confronting relevant bibliography, considering pedagogical and curricular implications. Thus, documentary research was complemented by critical analysis, seeking to understand how the BNCC and BNC-Training influence initial

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science teacher education for upper elementary grades and the approach to botanical content in school curricula.

Initial science teacher education for upper elementary grades

BNC-Training clarifies that the knowledge dimension includes "mastering the knowledge objects and knowing how to teach them". This vision is simplistic, as it conceives that having knowledge of one's area is sufficient for teaching. Science teacher education presents particularities that differentiate it from other knowledge areas. According to Gil-Pérez and Carvalho (2011), knowing the subject matter to be taught is only the beginning of the process. It is necessary to know the problems that have originated the construction of scientific knowledge, the difficulties and epistemological obstacles, the methodological orientations, and the interactions between science/technology/society. The authors (2011) discuss that science teacher education must transform students' spontaneous thinking and that this knowledge construction should have characteristics of scientific research. Table 2 highlights the 09 formative needs for science teachers:

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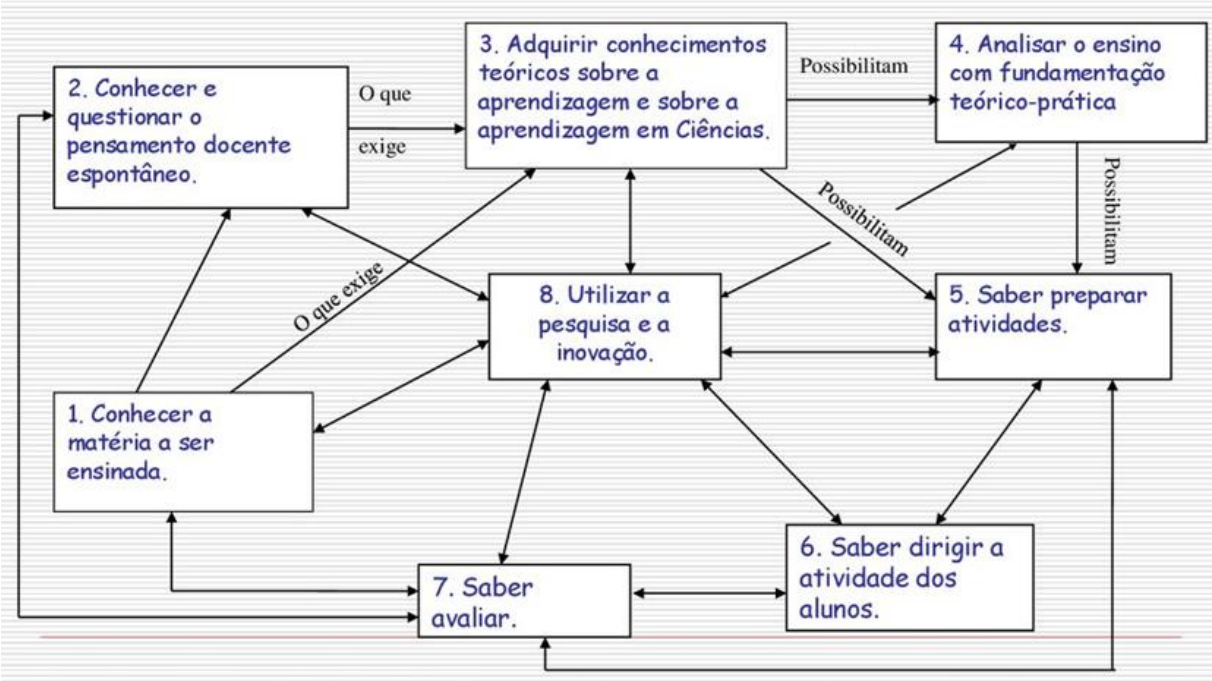
Table 2 – What science teachers must “know” and “know how to do”



Source: Gil-Perez and Carvalho (2011)

In professional practice activities during initial training for science teachers, it is expected that pre-service teachers will be exposed to diverse situations that foster engagement with innovative proposals and the exercise of reflection on their practice. However, what is observed in Undergraduate Programs in Biological Sciences is a content-heavy, fragmented curriculum, in which practical activities are limited to verification processes, with closed protocols that do not reflect the reality of scientific knowledge construction. The curriculum of Biological Sciences teacher education programs is, in most cases, very similar to that of the bachelor’s degree and trains biological researchers. Yet there is a difference between research on scientific knowledge and research on school knowledge. Research in the field of science education has underscored these differences, as have investigations in education, such as, for example, the alternative conceptions movement, inquiry-based teaching, and active methodologies (Costa and Venturi, 2021; Gomes and Teodoro, 2020; Almeida and Malheiro, 2022; Leão and Kalil, 2015).

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The professional engagement described in the BNC-Training includes "committing to one's own professional development." Thus, it is understood that, beyond the knowledge acquired during initial training, the teacher should remain up to date with recent scientific knowledge and its perspectives, possess knowledge of related subjects, select appropriate content, be prepared to deepen existing knowledge and to acquire new knowledge, and consistently question ideas considered "common sense." The teacher needs to be able to propose problem situations that are accessible, generate interest, and provide a preliminary conception of the task, guiding the scientific treatment of problems, directing learning activities, and facilitating enriching exchanges. A positive climate of functioning and organization must prevail in the classroom, which favors fruitful interactions between the class, the school, and the broader environment. In addition to all this, it is necessary to know how to assess and to connect teaching with didactic research.

Botany teaching in initial teacher education

Botany teaching is included in BNCC under the Thematic Unit "Life and Evolution," within the area of Natural Sciences. There are few topics in which the objects of knowledge show any relation to plants. It is noted that botany content appears in the 6th grade objects of knowledge, with the study of the cell as the unit of life; in the 7th grade, as part of the characterization and identification of ecosystem diversity; in the 8th grade, with the comparative study of the reproductive cycle and reproductive mechanisms of living beings; and in the 9th grade, with evolutionist ideas, as well as biodiversity preservation (Brazil, 2018a). It is also noted that the term "plants" is mentioned only once, in a single 8th-grade skill: "Compare different reproductive processes in plants and animals in relation to adaptive and evolutionary mechanisms (EF08CI07)" (Brazil, 2018, p. 349). Ursi, Freitas, and Vasques (2021) had already warned that, over the years, botany content has been decreasing in guiding education documents, including the BNCC, which indicates a progressive erasure and devaluation of these contents in curricula and, consequently, in classroom approaches.

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However, given how undergraduate teacher education curricula are usually organized, these lower-secondary contents are distributed across different courses, disconnecting morphological, physiological, ecological, and evolutionary aspects of plants. Especially in public universities, where research is tied to teaching, the organization of botany courses follows the research areas defined by the Brazilian National Council for Scientific and Technological Development (C*onselho Nacional de Desenvolvimento Científico e Tecnológico* — CNPq): paleobotany, plant morphology, plant physiology, plant taxonomy, and phytogeography (CNPq, 2022). The predominance of lectures followed by practical classes reinforces the training of future biologists and does not meet pre-service teachers' needs (Brando and Caldeira, 2009; Marchioretto and Moço, 2024). Santos and Valdeiras (2014) highlight that the curricular organization of higher education teacher preparation programs has little pedagogical alignment with elementary education, as they allocate far more hours to subject-specific components than to pedagogical components. Despite more recent curricular changes in teacher education, which regulated the inclusion of Practices as a Curricular Component (Brazil, 2015; Brazil, 2019), it is still observed that programs do not offer methodologies that support future teachers (Oliveira and Nobre, 2022; Marchioretto and Moço, 2024).

It is worth noting that, in most universities, the same professors who teach courses in the bachelor's programs also teach in the teacher education programs (Fonseca and Ramos, 2018; Oliveira and Nobre, 2022; Marchioretto and Moço, 2024). Teacher preparation for higher education is grounded in research, graduate studies, and public hiring processes, which assign greater weight to scientific production than to pedagogical skills. There is no requirement for specific pedagogical training for higher education faculty (Cunha; Brito; Cicillini, 2006; Ferreira, 2010). This reflects a minimalist view propagated in academia, namely, that having scientific knowledge and good communication skills is sufficient to be an effective teacher (Fischer, 2009). Such a view is incompatible with teacher education for Basic Education committed to student learning and does not meet the specific teaching competencies established by the BNC-Training.

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The methodology for teaching botany in Basic Education is reflected in the level of affinity and motivation students develop toward learning about plants. Plant education has long been neglected, not only in Brazil but also in other countries. Research identifies teacher education as one of the primary drivers of the invisibility of the ecological role of plants in the biosphere, reinforcing Plant Awareness Disparity (Hershey, 1996; 2002; Parsley, 2020; Ursi and Salatino, 2022).

It is important to consider that botany teaching in Basic Education is challenging, as traditional methods continue to dominate teacher preparation and are subsequently reproduced in classrooms. This perpetuates student disengagement from the content, which is often presented disconnected from their reality and lacking interdisciplinary connections. Consequently, students perceive botanical content as irrelevant and of little practical value (Souza, Batista, and Silveira, 2016). Thus, the lack of interest in botany is reinforced by teacher education curricula, which reproduce fragmented courses with no continuity and fail to explore conceptual interrelations. Even practical classes tend to be tedious, overly descriptive, and devoid of broader discussions regarding their purposes in Basic Education (Fonseca and Ramos, 2018). Ultimately, higher education programs graduate teachers who do not identify with plants and who see themselves as incapable of transforming this scenario. This is evidenced by the frequency with which school teachers rely exclusively on textbook narratives and theoretical lectures that reproduce the same traditional teaching model (Lajolo, 1996).

As shown, even within the field of botany, the content found in teacher education curricula does not integrate or relate to broader perspectives, nor is there an evident concern for developing teaching strategies tailored to effective student learning, as required by the BNC-Training. Santos and Valdeiras (2014) further emphasize that in-service teachers also have insufficient training in physics, chemistry, and virtually none in mathematics, an issue that hinders the development of interdisciplinary practices in schools, which are essential for science education. Despite official documents from the Brazilian Ministry of Education mentioning interdisciplinarity, the fragmentation of content is so deeply rooted in the current educational system that even the new science textbooks of the 2021 National Textbook Program (*Programa Nacional do Livro Didático* – PNLD 2021) still adopt the division of content into the three Thematic Units,

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without integrating them into a unified and interdisciplinary scientific language, as proposed by the BNCC.

It is urgent that universities rethink this curricular organization, seeking an interdisciplinary approach in teacher education so that such practices may be effectively implemented in schools (Prestes, Severo, and Moço, 2023). Ramos (2020) highlights that aligning teacher education curricula with the BNCC represents a significant opportunity for universities to break from the current curricular fragmentation, which compromises the articulation between theoretical and practical components in teacher preparation. On the other hand, teacher education cannot be reduced solely to the development of professional competencies.

Research indicates that the greatest challenge in the initial education of science and biology teachers, particularly regarding the teaching of botany, lies in the need for professional development oriented toward constructing a new teacher profile, one committed to research in education, citizenship formation, and sustainable development, through an interdisciplinary and contextualized approach (Fonseca and Ramos, 2017; Silva et al., 2016). From this perspective, both initial and continuing teacher education must be continually evaluated with critical rigor. Initial training in Biological Sciences programs must prioritize pedagogical content, emphasizing learning to become a teacher and encouraging innovative and complex methodologies and practices (Prestes and Boff, 2020).

According to Bizzo (2012), initial teacher education should promote the articulation between specialized biological knowledge and pedagogical knowledge. Tardif (2005) emphasizes that teaching experience is acquired over time by an active subject who learns by doing, thereby shaping one's identity, mastery, personality, and professional knowledge. The author stresses the importance of *teacher identity*, which is molded through countless interactions with colleagues and students. Regarding Biological Sciences degrees, Brando and Caldeira (2009) show that teacher identity formation may be hindered by an overemphasis on laboratory practicals, a curriculum that lacks articulation between disciplinary content and pedagogical components, and attitudes among higher education faculty that assign greater social value to the specialized scientist. In the specific case of botany, multiple authors reinforce that

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teacher identity must be developed through dialogue between universities and schools, aiming to strengthen pedagogical approaches to this specialized content and to provide methodologies that support future teachers in classroom practice (Fonseca and Ramos, 2018; Oliveira and Nobre, 2022; Souza, Batista, and Silveira, 2016).

However, higher education faculty are strongly shaped by a traditional teaching culture centered on transmission and memorization, with instruction oriented primarily around the professor. Salgado, Moço, and Silva (2019) warn that this pedagogical landscape should be fundamentally different, since teacher education must engage with the needs and proposals of school communities, moving beyond traditional concepts that no longer correspond to students' realities. The authors further argue that, for these new forms of teaching to take root in schools, interdisciplinary practice must be embedded in the curricula of teacher education programs. They also highlight that it is the responsibility of teacher education courses to ensure that their curricula include both specific disciplinary content and interdisciplinary approaches (Brazil, 2015). Therefore, there is an urgent need to reformulate training processes, considering the complexity of the transformations occurring in contemporary society.

Botany teaching and interdisciplinarity

The importance of interdisciplinarity is emphasized in the National Curriculum Parameters for Upper Secondary Education (Parâmetros Curriculares Nacionais para o Ensino Médio – PCNEM) and in all National Curriculum Guidelines (Diretrizes Curriculares Nacionais – DCN), which state that school subjects must pursue broad educational objectives related to all fields of knowledge and articulate themselves in an interdisciplinary manner. Although the BNCC maintains the area of Natural Sciences, it adopts the separation of content into three Thematic Units. Furthermore, interdisciplinarity becomes ambiguous when the document delegates responsibility for it to educational institutions (Brazil, 2018a).

Considering this context, botany teaching is situated within biological education, whose purpose is closely linked to the ecological importance of plants, as well as to the technological and economic applications of such knowledge for sustaining life on

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the planet. An interdisciplinary view of botany is possible and would help compensate for the absence of direct references to plants in the BNCC (Prestes, Severo, and Moço, 2023). However, the major challenge lies in understanding how such knowledge is built within initial teacher education. One way forward is to construct a curriculum that integrates the areas of knowledge and encourages collaborative teaching (Salgado, Moço, and Silva, 2019). Reflections on this topic are necessary for the development of innovative and interdisciplinary didactic and methodological strategies that may significantly improve the quality of botany teaching in Basic Education.

Botany teaching involves the study of the morphology, physiology, and reproduction of photosynthetic eukaryotic organisms and fungi. These organisms are responsible for maintaining oxygen and carbon dioxide levels in the atmosphere, primary production in all ecosystems, nutrient cycling, and the geochemical cycles of water and nitrogen, in addition to contributing to global thermal balance. Nevertheless, despite these essential functions for sustaining life on the planet, school botany content is commonly taught with excessive emphasis on nomenclature, morphological descriptions, and decontextualized information (Towata; Ursi; Santos, 2010). The didactic strategies adopted often reinforce an anthropocentric perspective that regards plants as mere providers of nature's services for human well-being (Calegari *et al*., 2021). This makes it difficult to understand morphological and physiological functions and characteristics from the perspective of both the plant and the planet.

Turning specifically to the fields of Science and Biology Education, their importance becomes evident when they expand students' conceptual and cultural repertoires, allowing for the "critical analysis of real situations" and enabling learners to make "more informed decisions, forming citizens who are more reflective and capable of transforming their reality" (Ursi; Freitas; Vasques, 2021, p. 25). For the authors, biological knowledge is linked to many contemporary issues, ranging from the maintenance of life to everyday problems, prompting students to reflect on environmental preservation, global climate change, energy sources, vaccination, and several other central themes of our time.

It is necessary to recognize that environmental resources are finite, limited, and dynamically interconnected. Therefore, society must rethink its strategic models of

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economic growth and social development (Canova and Prestes, 2020). Educational institutions, in designing their curricula, must incorporate actions that address the challenges faced by teachers and institutions regarding the implementation of interdisciplinary training processes.

Interdisciplinary botany centered on competencies

In conclusion, the current model of botany teaching in initial teacher education does not meet the specific competencies of teaching as established by the BNC-Training. The organization of botanical content, fragmented into various courses within teacher education programs, along with the number of hours allocated to disciplinary content rather than to the development of botany teaching strategies, fails to meet the "knowledge" dimension (see 1.1 in Table 1). It also fails to meet the "practice" dimension, as there is no planning of teaching actions that result in effective learning (2.1 in Table 1), given that "practices" within these curricula are limited to descriptive reports that merely complement specific botanical theory. Lastly, it fails to meet the "engagement" dimension, since it neither commits to student learning nor to the school's Pedagogical Project, nor to students' life and family contexts (3.2 and 3.3 in Table 1). In this context, it is important to emphasize that reducing teacher education to the development of competencies alone must be critically examined. The curriculum needs to be structured in a way that interweaves themes in accordance with interdisciplinarity, centered on the freedom to teach and learn, allowing students to relate their learning to their autonomy.

According to Ursi et al. (2018), achieving scientific literacy requires considering the different dimensions of botany teaching: environmental, philosophical, cultural, historical, medical, ethical, and aesthetic. Teachers must understand the environmental importance of plant functions on the planet through the integration of morphology, physiology, and the ecological relationships between plants and other organisms within ecosystems. Furthermore, teachers must identify students' particular learning difficulties regarding plant biology, especially those related to photosynthesis and evolutionary processes. Teachers should know their students and the environment

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in which the school is situated in order to create a safe and welcoming learning environment, according to contemporary learning theories. Such contextualization is achieved through classroom practice. In this regard, we agree that:

> [...] it is necessary to improve teacher education, and it must be practice-oriented. It is no longer possible to ignore the fact that our programs are extremely theoretical and have not responded to contemporary demands, learning outcomes, and the teaching of skills and competencies required by the BNCC. (Brazil, 2018b, p. 30)[2]

In this sense, the development of competencies and the integrated approach to scientific and pedagogical knowledge play a fundamental role in preparing young teachers. Teachers must develop an attentive perspective regarding the model of teaching and learning adopted by the school, as a model that fragments rather than unifies serves only to widen the gap in effective teaching and learning processes (Prestes; Boff, 2020).

BNC-Training supports a systemic vision, as illustrated in Figure 2, articulating initial teacher education, continuing education, and the teaching career. Collaboration among teacher education institutions, school networks, and Basic Education schools is encouraged, aiming for training that focuses on classroom practice and recognizes the importance of pedagogical knowledge and comprehensive education (Brazil, 2018b).

[2] Original: "[...] *é preciso melhorar a formação de professores e que ela deve ter foco na prática. Não é mais possível ignorar que nossos cursos são extremamente teóricos e não tem respondido as demandas da contemporaneidade, aos resultados de aprendizagem e ao ensino de habilidades e competências previstas na BNCC*" (Brasil, 2018b, p. 30).

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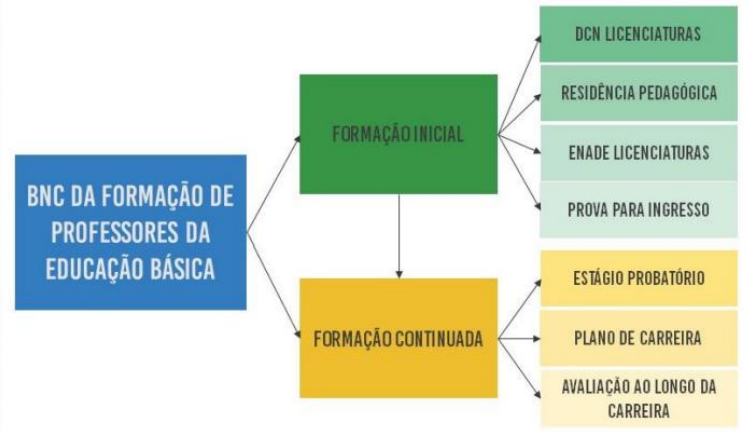
Figure 2: Proposed Systemic Vision



Source: Brazil (2018b, p. 29)

Future science teachers are central to this scenario, as they have the potential to establish a genuine connection between educational spaces and lived experiences, by analyzing them, renewing them, and re-signifying them, thereby creating a balance between theory and practice.

Final considerations

The teaching of botany in Basic Education is presented in a superficial and subjective manner, and the quality of student learning is closely linked to the initial education of science teachers. Therefore, reflecting on the applicability of the National Common Base for Initial Teacher Training in Basic Education (*Base Nacional Comum para a Formação Inicial de Professores da Educação Básica – BNC-Formação*) highlights interdisciplinarity as a possible pathway for botany teaching. This article demonstrates that interdisciplinary botany teaching within the initial education of science teachers must involve a curricular reorganization of courses so as to promote connections among their contents.

It also emphasizes that, in addition to being interdisciplinary, botany teaching must be contextualized. Thus, the development of the “knowledge” competency cannot be achieved without the “practice” competency, since only daily engagement with the school environment will reveal the pathways for understanding one’s students, how

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they learn, and determining the specific teaching strategies appropriate for each knowledge object of the National Common Curricular Base (Base Nacional Comum Curricular – BNCC). In this sense, teacher education programs must integrate the learning of specialized botanical content and adapt it to the context of each school, incorporating ecological studies of the local area and responding to students' interests in a democratic manner.

Higher education teacher educators must mediate this learning process for preservice teachers through collaborative work with the regional school network. Research is fundamental to teaching. It is necessary to establish articulation between the knowledge produced in universities and the knowledge developed by teachers in their practice.

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