EDUCAÇÃO EM FOCO
PROGRAMA DE PÓS-GRADUAÇÃO EM EDUCAÇÃO | UNIVERSIDADE DO ESTADO DE MINAS GERAIS

Conhecimentos Base e a formação docente: concepções de formadoras sobre as Lessons de Botânica na Educação a Distância

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RESUMO
A formação docente é essencial para o ensino da Biologia Vegetal nas escolas. Logo, o formador de professores (docente do Ensino Superior) tem papel de destaque, inclusive na Educação a Distância (EAD). Buscou-se identificar quais Conhecimentos Base/CB (segundo Shulman, Koehler e Mishra) foram contemplados em disciplinas sobre Botânica de cursos de Licenciatura EAD, bem como identificar as concepções de formadoras sobre tais conhecimentos, estabelecendo possíveis relações com suas escolhas pedagógicas. Sources documentais e entrevistas foram utilizadas na coleta de dados, sendo que estes foram interpretados a partir de análises de conteúdo e quantificações simples. Identificou-se uma maior ênfase nos Conhecimentos do Conteúdo. Os formadores destacaram suas dificuldades com a reduzida carga horária das disciplinas e com algumas especificidades pedagógicas da EAD. Ressalta-se a necessidade de formação dos formadores, permitindo-lhes a ampliação de conhecimentos sobre os cursos à distância e sobre os repertórios de ensino voltados a essa modalidade educativa.

PALAVRAS-CHAVE: Ensino. Licenciatura. Professores.

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Knowledge Bases and teacher training: trainers' conceptions about Botany classes in Distance Education

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ABSTRACT
Teachers training is essential for Botany teaching in schools. The teacher trainer (Higher Education teacher) has a prominent role, including in Distance Education (DE). The aim of this study is to identify which Knowledge Bases/KB (according to Shulman, Koehler and Mishra) were present in subjects about Botany in DE courses, as well as to identify the conceptions of trainers about those KB, establishing possible relationships with their pedagogical choices. Documentary sources and interviews were utilized for data collection. The information was analyzed using content analysis and basic quantification methods. It was detected an emphasis on Content Knowledge and close relations with the resources used in Learning Environments. The trainers highlighted the difficulties with the reduced time of the subjects and with some specific pedagogical aspects of DE. The training of trainers is crucial, allowing them to expand their knowledge about distance learning courses and their teaching repertoires focused on DE.

KEYWORDS: Graduation. Teacher. Teaching.

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Conocimientos de base y formación docente: concepciones de formadoras sobre las clases de Botánica en la Educación a Distancia

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RESUMEN
La formación del profesorado es fundamental para la enseñanza de Biología Vegetal en las escuelas. Así que, el formador de docentes (docente de Educación Superior) tiene un papel clave, incluso en la Educación a Distancia (EAD). Se buscó identificar qué Conocimientos Base (según Shulman, Koehler y Mishra) estaban contemplados en materias sobre Botánica de cursos de Graduación a Distancia. Se intentó reconecer las concepciones de las formadoras sobre estos conocimientos, estableciendo posibles relaciones con sus elecciones pedagógicas. Se utilizaron fuentes documentales y entrevistas para recoger datos, interpretándolos mediante análisis de contenido y cuantificaciones simples.Se identificó un énfasis en el desarrollo del Conocimiento de Contenidos de los universitarios, dificultades de las formadoras con jornada de trabajo de las asignaturas y con las especificidades de la EAD. Se destaca la necesidad de formación de formadores, permitiéndoles ampliar sus conocimientos sobre los cursos a distancia y repertorios didácticos enfocados en esta modalidad educativa.

PALAVRAS CLABE: Enseñanza. Graduación. Profesor.

Introduction

It is known that the teaching of Botany is indispensable, especially in the Brazilian context, where Plant Biodiversity is one of the largest in the world (Fioravanti, 2016), sparking heated discussions about the need for preservation and conservation of the country's flora. Despite this, the approach to "Plant Science" in educational environments has been informational and "memoristic," generating little interest among students and teachers about plants (Salatino; Buckeridge, 2016). To mitigate these and other challenges—such as Zoochauvinism (reported by Balas and Momsen, 2014), Botanical Unawareness (signaled by Ursi et al., 2021), and the neglect of Plant Biology in curricular documents (highlighted by Freitas et al., 2021), for example—the improvement of teacher training quality has been pointed out as one of the possibilities, enabling future educators to develop more engaging and motivating lessons for their students on botanical topics (Ursi et al., 2018; Barbosa, 2019a). In this regard, studies addressing teachers' knowledge and its construction (e.g., Koehler; Misrha, 2008; Shulman, 1986; 1987) have been valuable allies in improving teacher education.

Among research focused on teacher training, those investigating Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPACK) are particularly noteworthy. These studies reveal that educators with well-developed knowledge in these areas have a greater ability to provide more effective learning, tailored to the particularities of students (Koehler; Misrha, 2008; Shulman, 1986; 1987). In the context of teaching Plant Biology, this is no different, and it is acknowledged that enhancing teachers' pedagogical and technological knowledge related to the content of this field can make the approach to topics more engaging, minimizing the difficulties faced by students (Ursi et al., 2018; Barbosa, 2019a). In this respect, it is worth noting that, in recent years, both foreign and Brazilian researchers have delved into these issues, advancing the characterization of teachers' knowledge and, with that, improving the epistemology of this area of knowledge (e.g., Padilla and Garritz, 2015; Mouza, 2016; Ursi et al., 2018; Barbosa, 2019a, among others).

In this context, regarding PCK and TPACK, research shows that both originate from complex relationships of integration and/or transformation of other domains of knowledge, referred to as "Core Knowledge" (CK), which can be defined as "a set of skills and understandings, dispositions and values, character and performance that, together, underlie the ability to teach" (Shulman; Sykes, 1986, p. 5, our translation). Thus, among these types of knowledge, the following stand out: i) Content Knowledge (CCon), which refers to the educator's understanding of the topics to be taught; ii) General Pedagogical Knowledge (CPG), which refers to the general principles and strategies for

classroom management and organization, transcending the teaching topic; iii) Curriculum Knowledge (CCur), related to the programs and materials that serve as tools for the teacher; iv) Pedagogical Content Knowledge (PCK), defined as a "fusion" of content and pedagogy, enabling the teacher to understand how topics can be taught and adapted to the interests and abilities of each student; v) Knowledge of Students and their Characteristics (CAlu), which refers to the teacher's understanding of their students and their realities; vi) Knowledge of the Educational Context (CCEd), which varies among educational environments, communities, and cultures; and finally, vii) Knowledge of Educational Ends (CFEd), referring to the values and purposes (historical and philosophical) of teaching (Shulman, 1987).

With technological advancements and the inclusion of "technologies" in education, other forms of knowledge have been deemed necessary for teaching practice, and thus, additional "bases" were incorporated into those described by Shulman. Among them, we can highlight: viii) Technological Knowledge (CTec), which refers to the teacher's understanding of how to effectively use "technologies," recognizing when they can help achieve specific objectives; ix) Technological Content Knowledge (CTCon – the intersection between Technological Knowledge and Content Knowledge), which involves the teacher's understanding of how a specific "technology" relates to a particular teaching content; x) Technological Pedagogical Knowledge (CTPed – the intersection between Technological Knowledge and Pedagogical Knowledge), which pertains to the teacher's understanding of how "technologies" can be used for pedagogical purposes; and finally, xi) Technological Pedagogical Content Knowledge (TPACK – the intersection of all other knowledge), considered the foundation for good teaching with "technologies" (Koehler; Mishra, 2008). It is worth noting that, as explained by Mouza (2016), the focus of studies related to TPACK development is on "emerging technologies," which encompass digital tools, computers, and other resources that are part of the current teaching context.

Given the importance of the proper development of Core Knowledge for the appropriate training of a teacher and, consequently, for the enhancement of the quality of Botany/Plant Biodiversity lessons in educational settings (Ursi et al., 2018; Barbosa, 2019a; Ursi et al., 2021), we ask ourselves: which of these types of knowledge are being addressed during the training of Science educators in undergraduate courses, considering the mitigation of challenges related to plant topics? In this context, the results of some studies, such as Santos (2013), raise concern as they highlight how Botany instructors, teaching courses in Biological Sciences programs, focus their lessons on forming biologists, rather than Biology teachers, who are equally important in this context. Furthermore, there

is the current Brazilian scenario marked by the massive presence of Distance Education (EAD), as pointed out by Morais et al. (2021) and data from the Higher Education Census (Brazil, 2023). According to the latter, between 2011 and 2021, the number of enrollments in EAD undergraduate programs increased by 474%, while in face-to-face courses, it decreased by 23.4%. The study also reported that 87.68% of these initiatives are developed by private educational institutions and that, since 2018, the number of students enrolled in Distance Education Licentiate courses has exceeded those in the in-person modality (in this ranking, Pedagogy is the most commonly pursued Licentiate in EAD, and the Licentiate in Biology ranks 6th).

In this context, we find it pertinent to focus our investigation on distance learning, especially on the teachers who train future science educators (i.e., higher education instructors), as studies with this focus are still rare in the academic literature, as pointed out by some studies (e.g., Costa, 2017; Fraser, 2017; Koster et al., 2005). Therefore, we ask: in the view of these educators, what knowledge is considered important for training a Science teacher aimed at the proper teaching of botanical topics in Basic Education? Which of these types of knowledge are addressed by higher education instructors when preparing their Botany/Plant Biodiversity lessons for future teachers (undergraduates)?

Before attempting to answer these questions, we need to define who the teacher educator is. According to Koster et al. (2005), a teacher educator is the individual who guides and supports future educators during their formative process, contributing to its development. Therefore, one of the characteristics that differentiates them from teachers at other educational levels is, often, the duality of their functions, which can be linked to both teaching and research (Fraser, 2017). In Distance Education, other specificities are added to the educational practice, as this modality differs from face-to-face teaching in some aspects. For example, while in traditional education, communication between teacher and student typically occurs directly, in the same space and time, in EAD, the interaction is usually indirect (mediated by technological resources) and not always in real-time (Brazil, 2018). Thus, in EAD, additional activities are required of the educator, such as the preparation and writing of didactic and "technological" materials used in the courses, video lesson recordings, among others, demanding new skills that, in many cases, are distinct from those required in face-to-face teaching (Konrath *et al*., 2009).

In this context, while considering the specificities of both settings (in-person and distance learning), it is possible to say that the conceptions (as well as beliefs) of teacher educators can be reflected in their teaching methods and approach to content (Padilla; Garritz, 2015). Similarly, these conceptions can resonate in the strategies chosen to guide the teaching-learning process of students

(Fraser, 2017). Thus, we believe that understanding the conceptions of EAD teacher educators regarding the development of Core Knowledge for future teachers in Botany/Plant Biodiversity can provide us with insights that deepen our understanding of teacher education in these areas through distance learning.

Based on what has been outlined, the objectives of this research include: i) identifying which Core Knowledge (according to Shulman, 1987; and Koehler and Mishra, 2008) are addressed in Botany/Plant Biodiversity lessons within the curriculum of two Distance Education Bachelor's degree programs in Science (Subjects 1 and 2); ii) identifying the conceptions of teacher educators (higher education instructors), authors of the lessons in these subjects, regarding the development of Core Knowledge for the training of future educators in Botany/Plant Biodiversity through EAD, and drawing possible connections between these conceptions and the pedagogical choices made by the instructors. Further details on this research will be presented in the following section.

Methodology: Approach, Context, and Research Subjects

This research, with a qualitative approach (Lankshear; Knobel, 2008) and data amenable to simple quantification, presents part of the results of an extensive study conducted in two Distance Education Bachelor's degree programs in Science (further information in Barbosa, 2019a). This investigation was approved by an Ethics Committee (CAAE number: 77750517.1.0000.5464), and all participants signed an Informed Consent Form (ICF).

As previously discussed, given the importance of Botany and, especially, the approach to Plant Biodiversity in education, with the aim of expanding the understanding of the initial teacher training for Science educators ("licenciandos") in this regard, we investigated the lessons on Plant Biology from subjects in the curriculum of two teacher training initiatives delivered through distance learning: "Subject 1," part of a Bachelor's degree in Natural Sciences ("Course 1"), developed between 2012 and 2018; and "Subject 2," which was part of a sequential course in teaching fundamentals in Mathematics, Natural Sciences, and Humanities ("Course 2"), developed between 2014 and 2018. It is important to highlight that both initiatives were semi-presential and were developed by renowned public universities in São Paulo. Below, we summarize the syllabus and program for each subject (Tables 1 and 2). However, the detailed description of both can be found in Barbosa (2019a).

Subject 1, present in the third module of Course 1, lasted 10 weeks and covered various botany topics through video lessons, reading materials, exercises, in-person practical classes, and other

resources. The theme of Plant Biodiversity (BV) was addressed in most of these lessons, as evidenced in Box 1, which summarizes the structure of this subject.

Box 1 - Summary of Objectives, Resources, and Activities for Subject 1.

LESSON 0 – INTRODUCTION		**BV**
Objectives	Introduction to the subject, the syllabus, and the instructors.	–
LESSON 1 – Characteristics and Diversity of Red Algae		**BV**
Objectives	1. Present a brief history of the current landscape of plant classification, its origin, and diversity. Understand the main characteristics and diversity of the Phylum Rhodophyta (red algae).	YES
Resources	Text on the content; introductory video lesson; supplementary videos on the content; activities to investigate prior knowledge; text submission; and blog on the content.	
In-person Class	- Activity on the content.	
LESSON 2 – Characteristics and Diversity of Green Algae		**BV**
Objectives	1. Present one of the current perspectives on the classification of "green algae" for contextualized understanding by the student. 2. Characterize the biological diversity, the diversity of division types, and the diversity of life cycles of "green algae." 3. Provide an overview of the phylogenetic relationship between Charophyta and terrestrial plants..	SIM
Resources	Texto sobre conteúdo; videoLesson sobre conteúdo; vídeo complementar sobre conteúdo; e atividades de questionários e leituras sobre conteúdo.	
In-person Class	- Practical lesson on the content.	
LESSON 3 – The Conquest of the Terrestrial Environment by Plants Plant Biodiversity		**BV**
Objectives	1. Study the main morphological and reproductive adaptive requirements for the transition of plants from aquatic to terrestrial environments 2. Relate the morphological and reproductive adaptations associated with the colonization of the terrestrial environment by plants.. 3. Present the characteristics and importance of non-vascular embryophytes: liverworts, hornworts, and mosses. 4. Briefly contextualize the origin of tracheophytes (vascular plants).	YES
Resources	Text on the content; video lesson on the content; quiz activities on the content.	
In-person Class	- Practical class on the content.	
LESSON 4 – Tracheophytes and "Pteridophytes"		**BV**
Objectives	1. Briefly contextualize the evolutionary history of tracheophytes (vascular plants). 2. Characterize the biological diversity of seedless vascular plants ("pteridophytes"): lycophytes and monilophytes.	YES
Resources	Text on the content; video lesson on the content; activities on the content.	
In-person Class	- Practical activity on the content.	
LESSON 5 – Structure, Growth, and Development of Spermatophytes		**BV**
Objectives	1. Understand the importance of seeds in the evolutionary success of spermatophytes; 2. Comprehend the role of seeds in embryo protection; 3. Differentiate the main tissues that make up the plant body; 4. Understand the continuity of tissues throughout the plant body; 5. Characterize the anatomy of roots and stems in primary and secondary growth, as well as of leaves; 6. Become familiar with some specialized types of roots, stems, and leaves.	NO
Resources	- Text on the content; video lesson on the content; quiz; and activities on the content.	

In-person Class	- Practical activity on the content.	
LESSON 6 – Physiology of Seed Plants		**BV**
Objectives	1. Present plant hormones. 2. Explain how external factors influence plant growth. 3Explain the process of plant nutrition. 4Characterize the movement of water, inorganic nutrients, and photosynthetic products.	NO
Resources	Text on the content; quizzes on the content	
In-person Class	- Practical activity on the content.	
LESSON 7 – "Gymnosperms": Characterization, Diversity, and Geographic Distribution		**BV**
Objectives	1. Present the origin and general characteristics of gymnosperms.. 2. Characterize both extant and extinct gymnosperms..	YES
Resources	- Text on the content; video lesson on the content; quizzes; and activities on the content.	
In-person Class	- Practical activity on the content.	
LESSON 8 – Characterization of Angiosperms		**BV**
Objectives	1. Present the origin and general characteristics of angiosperms. 2. Characterize the development and life cycle of angiosperms	NO
Resources	Text on the content; video lesson on the content; activities on the content	YES
In-person Class	- Practical activity on the content.	YES
LESSON 9 – Current Classification of Angiosperms and the Economic and Ecological Importance of Plants		**BV**
Objectives	1. Present the current classification of angiosperms.. 2. Highlight the economic and ecological importance of angiosperms	YES
Resources	- Text on the content; video lesson on the content; quizzes on the content.	
In-person Class	- Field trip for plant identification.	
LESSON 10 – Review of the Main Plant Groups and Their Economic Importance		**BV**
Objectives	Weekly review.	YES
Resources	Final video lessons.	
Tasks	Course evaluation.	

Source: prepared by the authors.

Regarding the teacher educators of Subject 1 (“Professor 1” and “Professor 2”), both held degrees in the field of Biological Sciences, having completed academic master’s and doctoral programs in the area of Botany. At the time of this research, they taught Plant Biology at the undergraduate and graduate levels at a public university in São Paulo, and were also involved in continuing education for teachers.

Subject 2, in turn, covered various Biology topics over the course of 28 lessons, totaling 7 weeks. However, Botany was addressed only in Lessons 13, 14, and 15, which were part of Week 4.

Therefore, our investigation focuses on these lessons, summarized in Table 2 below. It is worth noting that the topic of Plant Biodiversity (PB) was addressed in all lessons related to Botany.

Box 2 - Summary of the Objectives and Resources Used in the Botany/Plant Biodiversity Lessons in Week 4 of Subject 2

Week 4 of Subject 2		**BV**
Objevtives	1. That the student is able to understand evolution as a starting point for the study of biodiversity; 2. That they are able to understand the principles of phylogenetic systematics; 3. That they are able to recognize and respect biodiversity and the values associated with it; 4. That they can reflect on contextualized teaching; 5. That they recognize non-formal spaces as important places for conservation practices..	–
Resources	-Video lesson 13: "Photosynthetic Organisms I"	YES
	-Video lesson 14: "Photosynthetic Organisms II"	YES
	-Video lesson 15: "Photosynthetic Organisms III"	YES
	- Core text 1 on the topic of lesson I	YES
	- Core text 2 on the topic of lesson II	YES
	- Core text 3 on the topic of lesson III	YES
	- Support video 1 on topics covered in lessons 13 to 15	NO
	- Support website: Botany Online	YES
Tasks	- Portfolio activity: development of a teaching strategy on "Plant Biodiversity" for high school students (student teachers were expected to prioritize activities contextualized to Basic Education students, avoiding lecture-based classes).	YES

Source: prepared by the authors.

Regarding the instructor who authored these lessons ("Professor 3"), it can be said that, like Professors 1 and 2, she held a degree in Biological Sciences and had completed academic master's and doctoral programs in the field of Botany. However, at the beginning of her career, she taught Science in Basic Education and became interested in the field of Education, which she then began to study. At the time this research was conducted, she was also working as a researcher in the area of teacher education in Botany, including through distance learning courses, and was affiliated with the same university as Professors 1 and 2.

Data Collection and Analysis

In order to identify the Base Knowledge (BK) components addressed in the Botany/Plant Biodiversity lessons of the investigated subjects (the first objective of this study), we accessed the Virtual Learning Environments (VLE) of Courses 1 and 2 and reviewed all the resources used by Professors 1 and 2 throughout the 10 weeks of Subject 1 (a total of 69 resources, including texts, exercises, video lessons, supplementary videos, and practical activity guides), as well as all those used in Lessons 13, 14, and 15 taught by Professor 3 (a total of 9 resources, which included texts, video lessons, a support video, a support website, and a portfolio assignment guide)).

To analyze these materials, we looked for evidence of the Base Knowledge (BK) components as proposed by Shulman (1987) and Koehler and Mishra (2008), which served as our categories, defined a priori and respecting the criterion of mutual exclusivity. Thus, when accessing an activity (for example, a reference text or an exercise on a given topic), the entire content was read with the aim of identifying the possible BK components present, which could be developed or mobilized by the pre-service teacher while completing the task. Likewise, a single activity could encompass multiple Base Knowledge components. Table 3 below describes what we considered as indicators of each BK component when analyzing the activities available in the VLE of each subject:

Box 3 – Evidence of Base Knowledge in the Activities of Subjects 1 and 2.

Content Knowledge (CCon)	Considered Aspects
General Pedagogical Knowledge (GPK)	Activities that presented information about content in the fields of Science and/or Biology.
Curriculum Knowledge (CK)	Activities that presented information about learning in general (e.g., topics related to Educational Psychology, Sociology of Education, conceptual profiles, etc.).
Pedagogical Content Knowledge (PCK)	Activities that presented information related to the Science and Biology curriculum, such as curriculum documents, hidden curriculum, among others.
Knowledge of Students and Their Characteristics (KSC)	Activities that connected specific content to possible ways of teaching it.
Knowledge of the Educational Context (KEC)	Activities that presented information allowing pre-service teachers to learn about their potential future students (e.g., approaches related to students' conceptual profiles in general, characteristics of students from previous and current decades, etc.).
Content Knowledge (CCon)	Activities that presented information about the local school, the Brazilian educational context, the history of education, among others.
Knowledge of Educational Aims (KEdA)	Activities that presented information about the goals of education, what students are expected to learn, laws that outline educational objectives, etc.
Technological Knowledge (TK)	As this is a distance learning course, it is believed that, in order to complete it, students must develop their own Technological Knowledge (TK), as argued by Alayyar et al. (2012), although this pedagogical intentionality is not always present on the part of the teacher educators.
Technological Pedagogical Knowledge (TPK)	Activities that presented information about how technology can support the teaching-learning process.
Technological Content Knowledge (TCK)	Activities that presented information about how technology has supported (and continues to support) the development of the fields of Science and Biology, as well as the development of specific content within these areas.
Technological Pedagogical Content Knowledge (TPACK)	Activities that presented (or requested) teaching approaches for specific botanical content supported by certain technologies

Source: prepared by the authors.

After identifying the Base Knowledge (BK) components in the activities, we counted how many times each of them was detected. Our aim was to verify, through simple quantifications, the frequency with which they were employed in the subjects, identifying possible emphases given by the teacher

educators during the planning of the lessons. The results of this process will be presented in Graph 1, in the "Results section".

To identify the professors' conceptions regarding the development of BK during the training of future educators in Botany/Plant Biodiversity via distance education (second objective of this study), we used two additional data sources (in addition to the analysis of the materials produced by the professors for the courses): i) transcriptions of the video lessons prepared by the instructors; and ii) interviews, aimed at deepening our understanding of the investigated aspects, as well as clarifying points that remained unclear during the document analysis. Regarding the first item, we based our approach on the argument by Arroio and Giordan (2006), who state that in distance education courses, video lessons represent one of the main ways learners access information on the instructional topics. Therefore, we deemed it appropriate to conduct a more in-depth analysis of these resources, rather than of other materials (such as support texts or exercises).

Accordingly, for the first item above, we fully transcribed the content of the 10 video lessons from Subject 1 and the 3 video lessons on Botany/Plant Biodiversity from Subject 2. After transcription, we conducted a content analysis following Bardin's (2011) methodology and searched for evidence of Base Knowledge in the instructors' discourse (see Table 4 below). Finally, we calculated the percentage of each BK component identified in the video lessons, considering the total number of excerpts ("context units," according to Bardin's definition, 2011) resulting from the analysis.

For the interviews, we prepared a script with a set of guiding questions, opting for a semi-structured model, as defined by Lankshear and Knobel. (2008):

1. What knowledge and skills should be developed in pre-service teachers so that they become effective teachers of Plant Biodiversity in Basic Education?
2. How do you think pre-service teachers should be trained in Plant Biodiversity in order to develop these knowledge and skills?
3. What were the main objectives of the lessons in your course?
4. What did the course coordinators ask you to do? (Did you have the freedom to design your own lessons, or was there a pre-established model?)
5. Regarding the tools used in your course, was there a specific standard you were required to follow? [If yes, did you want to use any other resource but were unable to? Why did you want to use it, and why couldn't you?]
6. Are there differences between teaching a Botany course via distance learning and teaching it in person? What are they?

In your opinion, do you believe that distance education can help pre-service teachers incorporate technology into their future teaching practice? [How would distance education support this process?

Since Subject 1 was jointly developed by Professors 1 and 2, they were interviewed simultaneously for 90 minutes. The instructors were free to respond to any of the questions and had the opportunity to complement (or not) each other's answers. Professor 3, in turn, was interviewed individually for 65 minutes. The interviews were recorded in both audio and video formats. Finally, full transcriptions of the interviews were produced, and content analysis was subsequently carried out following Bardin's (2011) methodology. As with the video lessons, the analysis focused on identifying evidence of the investigated Base Knowledge components in the instructors' statements (see Box 4).

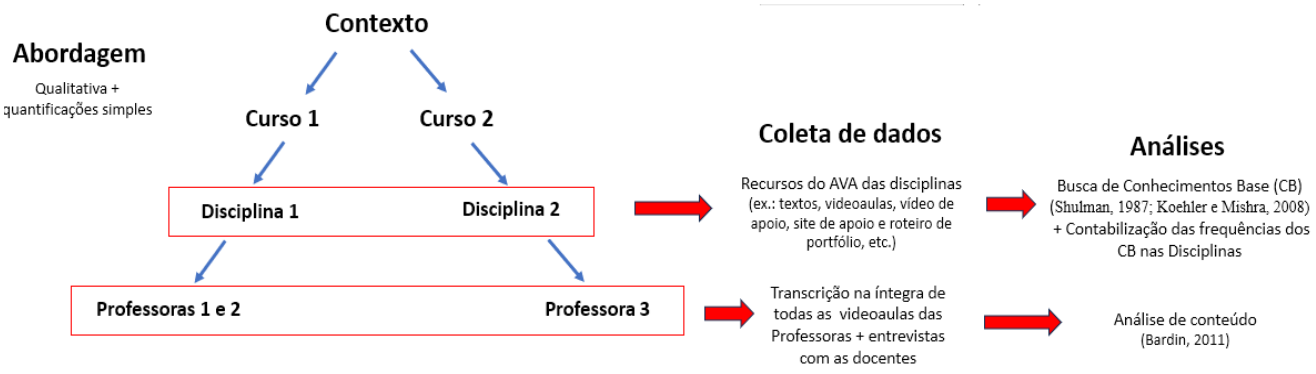
Box 4- Aspects considered for identifying the Base Knowledge components present in the video lessons and in the interviews with the teacher educators.

Base Knowledge	Aspects considered
Content Knowledge (CCon)	Statements by the instructors that included explanations about content related to Botany (conceptual, procedural, and attitudinal – Zabala, 1998).
General Pedagogical Knowledge (GPK)	Statements that contained explanations about general pedagogical content, for example: what contextualization is; how to contextualize; among others.
Curricular Knowledge (CurK)	Statements that included information on what is typically addressed about Botany in the curriculum and in Basic Education classes.
Pedagogical Content Knowledge (PCK)	Statements that provided explanations on how pre-service teachers can approach the teaching of specific Botany content.
Knowledge of Students and Their Characteristics (KSC)	Statements that offered insights into the general characteristics of Basic Education students for example, how Botanical Unawareness manifests among people.
Knowledge of the Educational Context (KEC)	Statements that included information about what students might encounter in school settings when teaching Botany.
Knowledge of Educational Aims (KEA)	Statements that addressed the educational goals related to botanical topics.
Technological Knowledge (TK)	Statements that included technical information about a specific technology.
Technological Pedagogical Knowledge (TPK)	Statements explaining how to use certain technologies in teaching.
Technological Content Knowledge (TCK)	Statements providing information about technological resources used in Science
Technological Pedagogical Content Knowledge (TPACK)	Frases das docentes que continham explicações sobre como os licenciandos devem proceder para ensinar determinado conteúdo botânico utilizando determinada tecnologia.

Source: prepared by the authors.

Aiming to summarize the methodology adopted in the present study, Figure 1 below provides an overview of key information:

Figure 1- Summary of the methodological steps of the present investigation.



Source: prepared by the authors.

Results: Foundational Knowledge and the Botany/Plant Biodiversity Courses

This section presents the results of the analysis of the resources available on the Virtual Learning Environments (VLEs) of Courses 1 and 2. Based on this and considering Table 1 (Methodology section), we observed that the resources used in Course 1 were mainly related to the presentation, demonstration, and reproduction of information (e.g., content-based texts, video lectures, topic-specific quizzes, among others). Accordingly, our analysis revealed a primary focus on the development of Content Knowledge (CCon).In contrast, although the Botany-related lessons in Course 2 also relied on information-delivery resources (such as video lectures and exercises see Box 2 in the Methodology section), we identified a stronger emphasis on the development of additional domains of Foundational Knowledge. The activity involving the creation of teaching sequences, for example, likely engaged other forms of foundational knowledge among the pre-service teachers (e.g., pedagogical, technological, and contextual knowledge, among others). The following Table 5 summarizes our findings:

Box 5- Foundational Knowledge Identified in the Lessons and Resources of Courses 1 and 2.

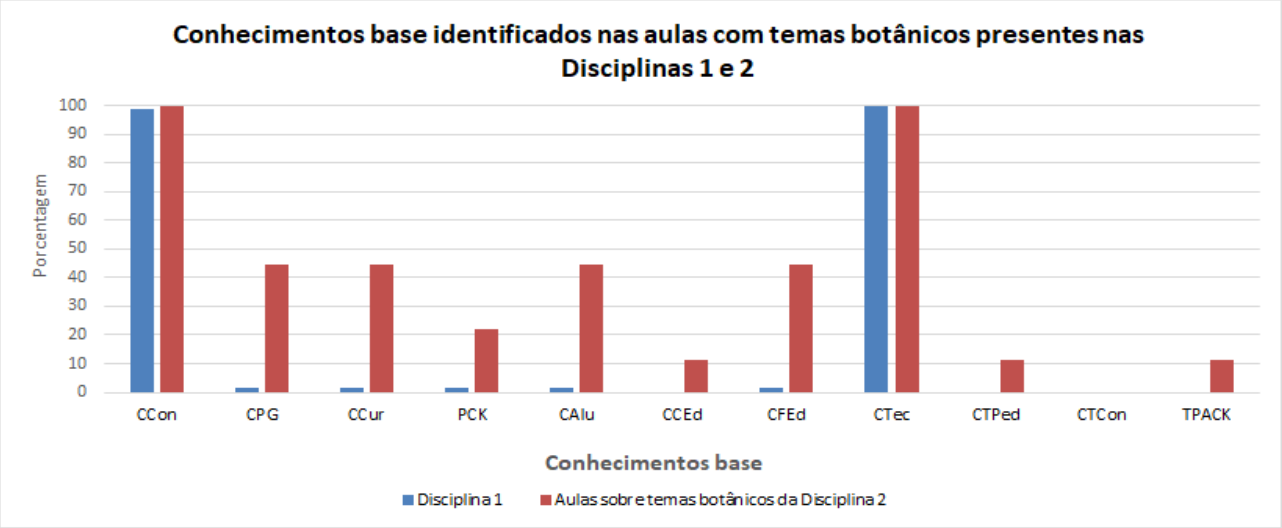
Subject 1		**Subject 2**	
Lessons and their Resources	**Identified FKs**	**Week 4 Lessons and Resources**	**Identified FKs**
Lesson 0	–	Video lesson 13	CCon, CAlu, CPG, CCur, CFEd
Lesson 1	CCon	Video lesson 14	CCon
Lesson 2	CCon	Video lesson 15	CCon
Lesson 3	CCon	Base text 1	CCon, CAlu, CPG, CCur, CFEd
Lesson 4	CCon	Base text 2	CCon
Lesson 5	CCon	Base text 3	CCon

Lesson 6	CCon	Supporting video 1 on the topics covered.	CCon
Lesson 7	CCon	Supporting website: Botânica Online.	CTPed, TPACK, CCon, CAlu, CPG, CCur, CFEd, PCK
Lesson 8	CCon, CPG, PCK, CCur, CAlu, CFEd	Portfolio activity: development of a teaching strategy on "Plant Biodiversity" for high school (contextualized activities that avoid lecture-based approaches	CCon, CAlu, CPG, CCur, CFEd, PCK, CCEd
Lesson 9	CCon	–	–
Lesson 10	CCon	–	–

Source: prepared by the authors.

Graph 1 below shows the percentage of each type of Base Knowledge identified after analyzing the Resources—that is, the 69 Resources from the LMS of Subject 1 and the 9 Resources from the LMS of Subject 2. It is evident that almost all of the Resources used in the first course addressed Content Knowledge (CCon), while a smaller portion involved other types of Base Knowledge (such as General Pedagogical Knowledge/CPG, Curriculum Knowledge/CCur, Pedagogical Content Knowledge/PCK, among others). Subject 2, in turn, showed a proportionally greater presence of these other types of knowledge in the Resources provided in the virtual environment.Regarding Technological Knowledge, following Alayyar et al. (2012), we consider that all activities carried out by student teachers in the LMS may help develop their Technological Knowledge (CTec). However, we emphasize that such pedagogical intentionality is not always present on the part of the teacher educator. It is important to note that in teacher education programs, a more balanced distribution of Base Knowledge is expected throughout the training process. Further reflections on this matter will be presented in the "Discussion" section".

Graph 1 - Percentage of Base Knowledge identified in the Lessons and Resources used in Subjects 1 and 2.



Source: prepared by the authors.

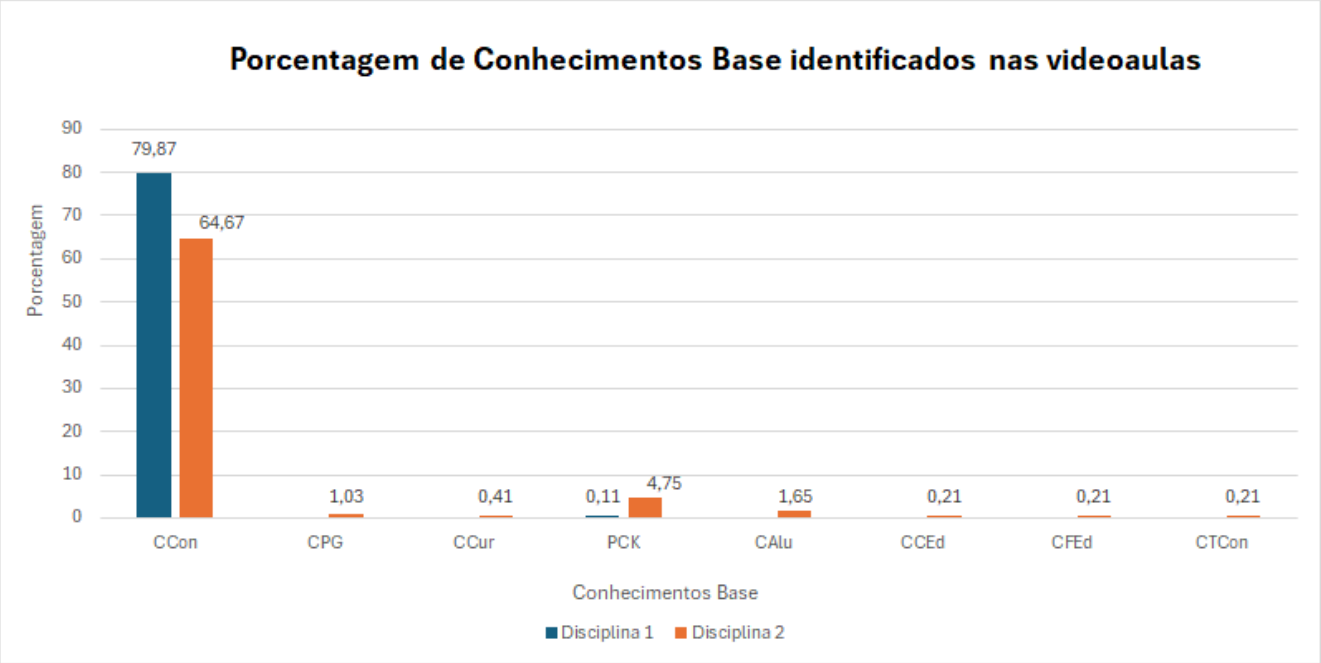
Teacher Educators' Conceptions on the Development of Base Knowledge Regarding Botany/Plant Biodiversity

As previously mentioned, based on the analysis of the courses, video lessons, and interviews, we sought to identify evidence of the educators' conceptions regarding the training of preservice teachers on botanical topics through Distance Education (particularly related to the development of teachers' Base Knowledge). In the previous section, we identified which of these types of knowledge were prioritized by the educators through the resources used in the Virtual Learning Environments (VLEs) of their respective courses. In this section, we present additional analyses, based on the video lessons and interviews with the educators.

It is worth noting that, due to the large number of excerpts resulting from the analysis of these materials, it was not possible to include all of them in this paper. Further details can be found in Barbosa (2019a).

From the video lessons, we observed that Professors 1 and 2 presented content primarily related to Botany, whereas Professor 3 also referred to botanical content but included references to other types of knowledge as well (which, to a certain extent, mirrored the structure of the lessons previously discussed). Graph 2 shows the percentage of Base Knowledge identified in the professors' speech during the video lessons of Courses 1 and 2. The 10 video lessons of Course 1 yielded a total of 929 excerpts (or "context units," as defined by Bardin, 2011), while the 3 video lessons of Course 2 yielded 484 excerpt.

Graph 2 - Percentage of Base Knowledge Identified in the Professors' Speech During the Video Lessons of Subjects 1 and 2.



Source: prepared by the authors.

Below, we present some excerpts from the video lessons that support these observations. In them, "VDA" refers to "Video lesson" and the numbers correspond to the context units established according to Bardin's (2011) framework. Therefore, "VDA1.33" means "Video lesson 1, excerpt 33":

Teacher 1: In addition to inheriting chlorophyll A, green plants have, over the course of evolution, produced or evolved to possess chlorophyll B. (This excerpt was classified as a potential contribution to the development of Content Knowledge in pre-service teachers).

Teacher 3: VDA13.41 Another interesting idea to bring plants closer to students' everyday lives is to think about botanical representations the connection that Botany can have with Art.(This excerpt was classified as a potential contribution to the development of Pedagogical Content Knowledge in pre-service teachers).

Through the interview analyses, it was once again observed that the instructors regard the development of Content Knowledge (CCon) including conceptual, procedural, and attitudinal aspects as one of the key aims in training pre-service teachers in Botany/Plant Biodiversity. This enables them to better design their lessons on the subject and to raise awareness about the preservation and conservation of plant biodiversity. Professor 3, in addition to emphasizing CCon, also referred to other forms of Base Knowledge (CB). In the excerpts below, we present selected statements from the instructors that illustrate these aspects. As outlined by Bardin (2011), the fragments are identified using "ENT" (referring to "interview"), followed by the code for the professor (P1, P2, or P3), and a

number that indicates the specific question and excerpt. Thus, the fragment "ENTP2.2.1" refers to "Interview with Professor 2, question 2, excerpt 1".

Teacher 2: ENTP2.1.1 *I believe they must have theoretical knowledge—definitely! Because there is this idea that concepts are not important. I think concepts are important because if they are not addressed, you end up with incorrect knowledge—you create a flawed understanding, right?* About the development of the pre-service teacher's conceptual Content Knowledge.

Teacher 1: ENTP1.1.13 *[...] because by knowing or understanding that diversity exists, we are able to understand and respect that diversity.* bout the development of the pre-service teacher's attitudinal Content Knowledge. Well, nowadays, we talk a lot about environmental conservation, about the importance of preserving resources for future generations, which is closely related to the issue of sustainability, right? And I think that in order to preserve the environment, you need to establish some sort of connection with it. Certainly, one of the connections you can create is through knowledge, right*?* About the development of the pre-service teacher's attitudinal Content Knowledge.

Teacher 3: ENTP3.1.3 *So, I would say that in initial teacher training, we end up working a lot on this: Pedagogical Content Knowledge, Pedagogical Knowledge, and Content Knowledge. But we can also go a bit further and address, for example, knowledge more closely related to context and to the students themselves*. About the development of a pre-service teacher's Base Knowledge.

When asked how undergraduate lessons should be conducted to ensure that such knowledge is developed by pre-service teachers, Teachers 1 and 2, in addition to highlighting the importance of presenting information to students, emphasized the need for practical components capable of developing procedural content (and attitudinal content, in the case of a visit to a botanical garden, for instance). Teachers 3, in turn, mentioned the necessity for pre-service teachers to develop other types of Base Knowledge (beyond content knowledge) through the creation of didactic sequences on a specific topic:

Teacher 1: ENTP1.2.9 *[...]Essentially, there has to be practice, in whatever form it takes. Often, we imagine practice as something that requires a laboratory, but what I mean is experimentation [...] practice can take place in a garden with a potted plant, in the classroom—what matters is the opportunity for experimentation [...] So I believe that practice makes it possible—it doesn't guarantee, but it makes it possible—to increase the chances of moving away from a fixed, standard model of knowledge. For instance: you'll have to dissect a flower. If someone hasn't had any practice, or the skill, the first time they'll probably tear it apart. Then they'll realize that tearing doesn't work. And so, they'll try various approaches, experiment with different ways to find and understand that structure, to observe it better.(On the development of procedural and attitudinal Content Knowledge*.

Teacher 2: ENTP2.2.3 *It is very difficult to imagine that a teacher can encourage their students to do things they themselves have not developed the habit of—whether in terms of knowledge or attitude, right? [...] So, in my view, teacher education programs, when we talk about Natural Sciences or Biology, must include practical activities at some point!(On the development of procedural Content Knowledge – CCon).*

Teacher 3: ENTP3.2.5 [...] *To work on the types of knowledge we want to develop, but perhaps not only the disciplinary content knowledge, right? I believe that even in the teacher's own discourse we can somehow interweave other types of knowledge [...] I always try to give students activities through which they can develop strategies, such as creating a didactic sequence related to the teaching of Plant Biodiversity, for example.(On the development of Content Knowledge – CCon – and other Base Knowledges – CBs).*

Regarding the objectives of the lessons, the teachers emphasized the importance of presenting a general overview of plants through an evolutionary perspective (development of Content Knowledge – CCon). Teacher 3 also highlighted the need for pre-service teachers to establish connections with the teaching of these topics:

Teacher 1: ENTP1.3.3 *The evolutionary decision, then, should lead us to adopt the new plant classification starting with red algae which appears in very few textbook.*

Teacher 2: ENTP2.3.1 *We had to cover all the plants in 60 hours, right?!*

Teacher 3: ENTP3.3.1 *[...]Define photosynthetic organisms, distinguish them from plants, identify their characteristics, recognize the major groups through a strongly evolutionary approach, and discuss some of the challenges and possibilities of teaching Botany.*

The emphasis placed by the instructors on the development of the Content Knowledge (CCon) of the preservice teachers was likely due to the workload established by the organizers of Courses 1 and 2 for their respective subjects. Teachers 1 and 2, after discussions with the coordination team of Course 1, managed to align the workload of Subject 1 with that of the Zoology subject (also part of the same course). This allowed them to ensure that the "minimum content" (according to them) would be covered for the preservice teachers. Teacher 3, in turn, also reported difficulties regarding the workload allocated to Botany in Course 2 only 3 out of 28 Biology lessons):

Teacher 2: ENTP2.4.2 *In the course we took part in [Course 1], this was one of the main points we fought for: to ensure that there would be, at that time when we were contacted and discussed our participation, a proper place for Botany. Initially, Botany was allotted only a 30-hour subject, and we debated and tried to argue, and we managed to have the subject match others like Zoology, for example, so it became a 60-hour subject. Therefore, it gained twice the space in the materials and related activities.*

Teacher 1: ENTP2.4.9 *We reached consensus discussions about fighting for more space in order to somehow ensure a minimum amount of content for the preservice teacher in that distance learning course. Botany was one of those subjects.*

Teacher 3: ENTP3.4.1 *Look, I wish this subject had lasted three terms, right? But it was only one! We had three lessons to talk about plant diversity. [...] So, I discussed with them over the course of three lessons, which is very little, right?*

In this context, we also observed that the choices of AVA resources made by the instructors (as well as the focus on Content Knowledge – CCon) were influenced by their conceptions regarding preservice teacher education through distance learning. Accordingly, Teachers 1 and 2 emphasized tools aimed at developing CCon, which aligns with the objectives of Subject 1 (Box 1 – Methodology), while Teacher 3 sought to diversify the resources in order to foster the development of other types of Base Knowledge also in line with the objectives of Subject 2 (Box 2, Methodology section):

Teacher 2: ENTP2.5.7 *All ten weeks included theoretical activities—actually, correction: reading, not theoretical activities! Reading! Most weeks featured an associated video lesson […] exercises, so throughout the entire period, within each chapter, and to wrap it up, let's say, the cherry on top at the end of the week was a hands-on activity related to that week's topic.*

Teacher 3: ENTP3.5.5 *But we cannot restrict Distance Education to just video lessons. […] I always include readings of articles—for example, a basic text on Botany itself, on Plant Classification, Evolution—along with texts from the field of Education, especially Science and Biology Education, that address some aspect related to teaching. […] So, even in EAD, I think it's essential for the instructor teaching the subject to go to a laboratory, right? […] But I also taught how to make a homemade herbarium sheet, and I asked the students to create a herbarium. […] I didn't have a face-to-face meeting with them, but they carried out a practical activity that the tutors called a "virtual herbarium".*

Regarding the difference between face-to-face and distance education, Teachers 1 and 2 emphasized that distance education demands greater autonomy and protagonism from the student, while Teacher 3 highlighted differences in interaction, the time students dedicate to studying, as well as their learner profiles:

Teacher 1: ENTP1.6.9 *[...]talvez o EAD, por ser uma questão que depende muito mais do aluno.*

Teacher 2: ENTP2.6.2 [...]*Face-to-face learning allows for much more passivity, doesn't it? Distance education does not.*

Teacher 3: ENTP3.6.7 [...] *The type of interaction is different, but I believe that, in distance education, you can actually have more interaction, surprisingly enough [...] I also think that the amount of time you're in contact with students in the virtual environment is, theoretically, limited [...] so you have to consider: they have the time to watch a video lesson... how much time will they have? One hour to do all of that? Managing time is very different [...] so students often end up... most of them work, most of them are pursuing a second degree.*

Finally, the teachers considered that distance education (DE) can help students develop their knowledge related to the integration of technologies into teaching:

Teacher 1: ENTP1.7.3 *So, I believe that the generations enrolling in distance education programs are, naturally, younger generations. Younger individuals are signing up, so they will find it easier to use that tool for their own learning. I assume that, for this generation, it will also be easier to use that tool with their own students because, for them, it won't involve two separate learning processes.*

Teacher 3: ENTP3.7.5 *just by being immersed in that environment, the preservice teacher will inevitably learn basic things, such as submitting an assignment, sending an email, participating—even if only minimally—in a forum at some point.*

Discussion

Considering the results from the previous section and revisiting the structure of the subjects presented in the Methodology section (Boxes 1 and 2), the first aspect that draws our attention concerns the presentation of the Lesson objectives. It is evident that, in the case of Subject 1, Teachers 1 and 2 presented these objectives mostly from the teacher's perspective—that is, based on what they

intended to teach the pre-service teachers. This is noticeable through the verbs used by the instructors, such as “Present,” “Characterize,” “Highlight,” among others (Box 1). In contrast, in Subject 2, the teaching objectives were presented by Teacher 3 from a student-centered learning perspective, as illustrated by expressions such as “That the student be able to,” “That they may reflect on,” “That they recognize,” among others (Box 2).

From this, we identify elements that align the conceptions of Teachers 1 and 2 with what Gil (1997) defines as a “teaching process,” which occurs when the educator concentrates efforts on the act of teaching, considering it important to transmit information to students. In our view, this explains the emphasis placed on CCon by the instructors throughout the Lessons (Box 5 and Graphs 1 and 2 above). It is worth noting that this conception is quite prevalent among higher education faculty, as evidenced by Padilla and Garritz (2015), and may be related to the academic background of these instructors. As Abell et al. (2009) explain, academic graduate programs remain the primary means of training university professors, and most of these programs prioritize the development of subject-matter expertise (emphasizing content mastery and research-related skills), which may later be reproduced in their teaching practice.

In the case of Teacher 3, we observe signs that align her approach with what Gil (1997) refers to as a “learning process,” which occurs when the focus is on the student. Evidence for this includes the way the Lesson objectives in Subject 2 were presented, as discussed earlier, as well as the greater engagement she promoted in relation to the development of other types of Foundational Knowledge by the pre-service teachers (Box 5 and Graphs 1 and 2 above). In this context, it is believed that the instructor’s professional experience (such as her prior work in Basic Education, in addition to her research focus on Botany teaching as noted in the “Methodology” section) may have contributed to this approach.

In this context, the emphasis placed on the development of Content Knowledge by the pre-service teachers in NO should not, at first, be viewed as a negative aspect, as it aligns with the literature in the field. Özden (2008), for example, emphasizes that knowing the subject to be taught, in addition to enabling the appropriate approach to the Lesson topics, allows the educator to make more effective choices regarding teaching strategies and resources, with a view to enhancing student learning. However, as argued by Daehler et al. (2015), it is important that the other types of Foundational Knowledge also be addressed regularly and in an integrated manner during teacher education, allowing future teachers to develop educational practices that are more attuned to current teaching demands, such as connecting topics to the learner's world, promoting student agency, and

developing competencies and skills that enable them to participate more fully in society. In this regard, we believe it is important that these other dimensions of knowledge be more prominently included in future editions of these courses or in other contexts similar to the one investigated here.

With regard to procedural and attitudinal Content Knowledge, we observed that all three instructors consider it important for the training of pre-service teachers in Botany/Plant Biodiversity. As justification, they emphasized the need for students to develop skills and competencies related to "scientific practice," such as observation and experimentation. Indeed, the conceptions expressed by the instructors regarding hands-on activities in distance education are in line with what researchers identify as important, even for topics in science education (e.g., Crippen *et al*., 2013; Fraser, 2017). Therefore, it is considered essential to seek ways to implement such activities, despite the challenges they may face in distance education settings (Crippen *et al*., 2013), as laboratory work is one of the main strategies for promoting inquiry-based learning. This approach enables pre-service teachers to gain a deeper understanding of the nature of science (Fraser, 2017), which is fundamental to Scientific Education. Specifically regarding Botany, it can also be affirmed that such activities are essential, especially considering that some of them (such as field trips) may be valuable tools for overcoming certain challenges in teaching the subject such as plant blindness (Ursi *et al*., 2021), for example. Moreover, they may contribute to fostering more positive attitudes toward the preservation and conservation of flora, as some studies have reported (ex.: Ursi *et al*., 2018).

Regarding the pedagogical choices made by the instructors and the focus on the development of CCon (conceptual, attitudinal, and procedural Content Knowledge), we observed that the workload assigned to the subjects contributed to this outcome. The teachers' responses to the fourth interview question drew our attention for at least two reasons. The first concerns the marginalization of Botany in curricular proposals (including the new National Common Core Curriculum—BNCC), a situation also pointed out by Hershey (1996) and Freitas et al. (2021), which has negatively impacted Lessons on Plant Biology in schools. The second noteworthy point is that, at first, Course 1 allocated a greater number of hours to Zoology, revealing how "zoochauvinism" (as explained by Balas and Momsen, 2014) is also present in Higher Education. One potential consequence of this scenario, had the workloads of these subjects not been equalized, would be a tendency among pre-service teachers to emphasize Zoology in their future Lessons in basic education, thereby perpetuating the regrettable vicious cycle in the teaching of Plant Biology, as discussed by Salatino and Buckeridge (2016). Thus, it is essential for teacher education programs in Science and Biology whether in-person or distance learning to address these concerns.

With regard to the resources chosen by the instructors for their Lessons in the Virtual Learning Environments (VLEs), we observed an effort to diversify them, which we view positively, in light of Masetto's (2003) assertion on the need for higher education instructors to vary their teaching approaches to meet different learning objectives. However, in the case of Teachers 1 and 2, there was a marked focus on tools aimed at presenting, demonstrating, and reinforcing information, such as texts, exercises, and video lessons this latter being among the most frequently used resources by the instructors. This aligns with the ideas previously discussed by Arroio and Giordan (2006). Teacher 3, on the other hand, although also acknowledging the relevance of video lessons for addressing topics in distance education courses, reported feeling uncomfortable with their overuse in Subject 2, suggesting that she may have sought to avoid an overemphasis on CCon. In this regard, as Fraser (2017) argues, the exclusive use of tools focused on information transmission (such as video lessons and texts) does not ensure the development of other types of knowledge and skills that are equally essential for training Science teachers in distance education. This issue deserves critical attention from distance learning programs.

As for the development of technological knowledge, as previously mentioned, studies (such as those by Alayyar *et al*., 2012) have shown greater improvements in attitudes and technological skills among teachers who participated in blended learning courses compared to those enrolled only in in-person programs. This finding aligns with the conceptions expressed by the instructors. Nevertheless, it is important to stress that simply being immersed in a Virtual Learning Environment is not sufficient for pre-service teachers to learn how to use such resources effectively for teaching purposes. Therefore, as Koehler *et al*. (2013) argue, teacher educators must be attentive to these aspects, ensuring that future teachers learn how to use "technologies" pedagogically, thereby overcoming technocentric approaches.

Regarding the differences between in-person and distance education, Teachers 1 and 2 primarily mentioned the student profile, emphasizing that distance education students must be more autonomous and take greater ownership of their learning process. This observation aligns with findings from studies in this field (e.g., Vieira et al., 2020). However, as highlighted by Palloff and Pratt (2004), for autonomous learning to occur, distance learners must be able to manage their study time, set priorities, express their doubts, interact with peers and instructors, share information, and use technological tools safely, among other requirements. In this regard, Lubian *et al*. (2016) point out that, since these students are often adults who usually have jobs and professional responsibilities, they tend to engage in passive learning, merely completing the tasks assigned to them. Therefore, it

is essential for distance education instructors to support students in developing autonomy and seeking knowledge, helping them become more active participants in their own learning.

Teacher 3, in turn, also highlighted other differences, such as the degree of interaction and the amount of time students dedicate to activities, both of which are supported by the literature in the field (e.g., Costa, 2017). It is likely that this instructor demonstrates a deeper understanding of the distance education audience, as this has been one of the core themes of her research career.

In the specific context of distance education, Belloni (2001) emphasizes that instructors who typically work in face-to-face settings, when transitioning to distance education, must understand that: (i) they need to shift from the role of master to that of partner, being available to assist students as needed; (ii) comprehensive and ongoing professional development is necessary; (iii) diverse resources should be used to support student learning; and (iv) knowledge should be built collectively, with teamwork being encouraged, among other possibilities. Despite this, Mill (2012) notes that such training for distance education instructors does not always occur. Instead, many educators learn to teach in distance programs through their own experience in the modality what the author refers to as 'meta-training'. This was indeed the case for the Teachers-authors of Subjects 1 and 2 examined in this study.

Based on these considerations, it is essential to promote the training of distance education instructors, taking into account the specific characteristics of the modality (Note: we believe that training for in-person teaching is also crucial; however, this investigation focused specifically on distance education instructors). In agreement with Barbosa's (2019b) observations, we consider it pertinent that such training be grounded in pedagogical models that promote student knowledge construction and seek learning strategies suited to new educational contexts, while also offering support to distance education instructors. Furthermore, as Costa (2017) suggests, it is important to offer courses focused on the usability of Virtual Learning Environments, online instructional material writing, audiovisual language and speech techniques, studio-based Lesson recording, among other possibilities.

Final considerations

This study adds to a growing body of research aimed at deepening the understanding of teacher education in Botany/Plant Biodiversity through distance learning. However, it is important that

further investigations with a similar focus be conducted, in order to expand the reflections initiated here including from the perspective of other areas of biological knowledge, thus enabling comparisons with the context of Plant Biology.

We identified the types of Foundational Knowledge addressed in two distance education courses on Botany/Plant Biodiversity. In addition, we sought to understand the conceptions of the instructors (who were also the authors of the courses) regarding these aspects, as well as to outline possible relationships between their conceptions and the pedagogical choices they made.

From this, we can offer a few considerations regarding the present research. First, concerning the methodology adopted, we highlight that similarly to other researchers (e.g., Voogt et al., 2013) we encountered difficulties in delineating the categories of Foundational Knowledge, due to the interrelated nature of these types of knowledge. This made it challenging to define clear boundaries between them, and thus we drew on the explanations of Graça (1997), choosing to carry out this process through inference, as done in other studies with a similar focus. Even so, we believe our categorizations were adequate to meet the objectives of this investigation.

With regard to the development of pre-service teachers' Foundational Knowledge (FK), and consequently to the pedagogical choices made by the instructors (strategies and didactic resources), we identified a strong emphasis on Content Knowledge (CCon) and on tools capable of conveying this knowledge (such as texts and video lessons), particularly in the case of Teachers 1 and 2. These findings are consistent with other studies and reinforce the need for teacher education programs to pay greater attention to the development and integration of other forms of FK, which are equally important for effective pedagogical practice.

Concerning the strategies and didactic resources used for teaching Botany, the literature recommends the use of in-person practical Lessons (capable of developing students' procedural and attitudinal knowledge, beyond conceptual content), as mentioned by the instructors, along with tools that promote greater learner agency and increased interaction between students, instructors/tutors, and peers (e.g., forums, chats, wikis, among others). However, we found that these latter aspects were infrequent in the courses analyzed, which limited opportunities for students to enhance their technological skills, even though Virtual Learning Environments can be promising in this regard, as noted by Alayyar (2012).

Regarding the Botany curriculum, we identified that both programs allocated limited space to this subject, with evidence of "zoochauvinism" in Course 1. Therefore, we reaffirm the importance

of properly including Plant Biology in curricular documents, given its ecological, social, political, and economic significance for building a society with more sustainable attitudes.

Finally, and without closing the debate, it is essential that distance education teacher training programs develop proposals that align with the expectations of their target audience. To this end, investing in the training of instructors is crucial, as distance education has specific characteristics that demand skills and competencies distinct from those required in face-to-face teaching—an aspect also supported by the literature in the field.

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