

The Profile of Palaeontology Teaching in Undergraduate Courses in Brazil

Everton Fernando Alves ^a
Débora Liemi Tanji ^a
Carolina Zabini ^a

^a Universidade Estadual de Campinas (UNICAMP), Programa de Pós-Graduação em Ensino e História de Ciências da Terra (PEHCT), Campinas, SP, Brasil.

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ABSTRACT

Background: Currently, palaeontology professors have been challenged to update and incorporate innovative teaching approaches into their planning to help students develop the necessary skills and competencies. However, today there is a mismatch between the current and the ideal teaching profiles. **Objective:** To describe the palaeontology teaching profile in undergraduate courses in Brazil. **Design:** Descriptive and exploratory study. **Setting and participants:** Palaeontology professors (n=37) in undergraduate courses at several Brazilian higher education institutions. **Data analysis collection:** Data were collected through a semi-structured online form (survey), triangulated and categorised into (a) general characteristics, (b) teacher education, (c) teaching experience, (d) undergraduate courses, (e) curriculum, syllabus, and programme discussion meetings, (f) inter and multidisciplinary, and (g) curriculum. **Results:** Despite the limited scope (small sample size), the study results guided the focus of the research and improvement efforts, as there are still many difficulties and challenges to be overcome to raise the quality of teaching in undergraduate palaeontology across the country. **Conclusions:** The data from this study can serve as a valuable basis for professors-researchers, educational managers, and policymakers interested in implementing innovative continuing education programmes and in supporting management and policy decisions regarding potential reforms of palaeontology teaching in Brazilian undergraduate courses in higher education institutions.

Keywords: Teaching; Geoscience education; Teacher education; Pedagogical practices; University education.

¹Corresponding author: Everton Fernando Alves. Email: efalves.mga@gmail.com

O perfil do ensino de paleontologia em cursos de graduação no Brasil

RESUMO

Contexto: atualmente, os docentes de paleontologia têm sido desafiados a se atualizar e incorporar em seus planejamentos abordagens inovadoras de ensino, a fim de auxiliar os estudantes a desenvolverem habilidades e competências necessárias. No entanto, existe hoje um descompasso entre o perfil do ensino atual e o ideal. **Objetivo:** descrever o perfil do ensino de paleontologia em cursos de graduação no Brasil. **Design:** estudo descritivo e exploratório. **Ambiente e participantes:** docentes de paleontologia (n=37) em cursos de graduação de diferentes IES brasileiras. **Coleta de análise de dados:** os dados foram coletados por meio de um formulário *on-line* semiestruturado (*survey*), triangulados e categorizados em (a) características gerais, (b) formação do docente, (c) experiência docente, (d) cursos de graduação, (e) reuniões de discussão de currículo, ementa, e programa, (f) inter e multidisciplinaridade, e (g) currículo. **Resultados:** apesar da abrangência limitada (pequeno tamanho da amostra), os resultados do estudo fornecem orientação sobre onde os esforços de melhoria e pesquisa devem se concentrar, uma vez que ainda há muitas dificuldades e desafios a serem superados para se elevar a qualidade do ensino da paleontologia na graduação em todo país. **Conclusões:** os dados deste estudo podem servir como uma base útil para professores-pesquisadores, gestores educacionais e formuladores de políticas interessados em implementar programas inovadores de formação continuada e em apoiar decisões de gestão e políticas a respeito de potenciais reformas do ensino de paleontologia em cursos brasileiros de graduação em instituições de ensino superior.

Palavras-chave: Docência; Educação em Geociências; Formação Docente; Práticas Pedagógicas; Ensino Superior.

INTRODUCTION

In Brazil, palaeontology is a curriculum component in undergraduate courses in biological sciences (CBIO), geology and related areas (Back, 2019). In this way, the courses guarantee the basic palaeontological content for understanding the geological and biological evolution of the Earth, biodiversity and climatic factors, ensuring the future professional's scientific and social formation (Schwanke & Silva, 2010; Farias, Barros & Soares, 2017).

During the undergraduate years, students usually receive a grant to develop their projects and acquire initial contact with teaching different levels of basic education (Massi & Queiroz, 2015).

The formative process of palaeontologists in Brazil begins when the students take their first palaeontology course in university or college. It ends when the former students become professors in a university department. This

journey takes at least eight years of study, considering four years of undergraduate studies, two years to develop a master's thesis and three to four to develop a doctoral thesis (Zabini, 2017; Peyerl & Bosetti, 2021).

To qualify as a palaeontologist in Brazil, the individual must have a master's and/or doctoral degree in a postgraduate programme with a concentration area in palaeontology, developing a project in one of the several research lines the programmes offer (Siciliano & Leta, 2020). An important aspect to mention is that there is no specific undergraduate course in palaeontology in Brazil (Zabini, 2017), a situation that is similar to other Latin American countries. In this regard, Argentina is the only Latin American country to offer the course at the undergraduate level (Fernández et al., 2014).

As it happens in other countries, in Brazil, recently qualified PhDs spend several years in postdoctoral research positions, generally treated as second-class jobs, before securing a permanent job (Springer et al., 1997; Butler & Maidment, 2018). In the United Kingdom, for example, less than half (44%) of palaeontologists remain in university and achieve permanent jobs, which creates dismay with the academic job market (Butler & Maidment, 2018).

The career as a palaeontologist in Brazil is generally offered by public higher education institutions (HEIs), with a lower incidence in private institutions. Public bodies do not frequently open public tenders in palaeontology, and when they do so, the number of vacancies is quite limited (Zabini, 2017). Once a vacancy is obtained, the palaeontologist, who, from then on, becomes an *academic palaeontologist* (Flessa & Smith, 1998), can promote the pillars of education: teaching, research, and extension services.

As for the labour market for academic palaeontologists in Brazil, the Ministry of Education portal (e-MEC) shows that the total number of active undergraduate CBIO courses in the country is 1,067, considering those from public and private institutions in distance education (DE) and face-to-face teaching (Brasil, 2022a). In turn, the Brazilian Society of Geology (Sociedade Brasileira de Geologia - SBG) reports on its website 32 undergraduate courses in geology in Brazil (Cordani et al., 2018; SBG, 2021), while the e-MEC website lists 34 active university courses (Brazil, 2022a).

Looking at these raw numbers, that is, 1,067 courses in biology and 34 in geology, one can imagine that there is a wide field of activity for palaeontologists to act as professors in Brazil. However, two aspects distance them from this reality in the country: 1) palaeontology courses are not always

taught by qualified palaeontologists, since other specialists are allowed to teach the basic principles of this area if they receive training during their undergraduate course and take additional training on the subject, and 2) not all undergraduate courses in the areas mentioned above offer the isolated subject of palaeontology in their official curriculum, which means that the contents may be condensed and associated with those of geology in a broader subject of Earth Sciences (Diehl, 2014), which eventually reduces specialised job offers.

Therefore, it is possible to recognise that vacancies for academic professors in palaeontology are rare (Butler & Maidment, 2018), leading palaeontologists to accept other positions whose realities do not necessarily correspond to personal expectations and formal qualifications. The number of palaeontologists in Brazil is difficult to estimate. The closest available data is found in the Brazilian Society of Palaeontology (SBP) database, which points to 713 associates registered, including professionals, students, and experts from other countries (Siciliano, 2018; Resende & Rodrigues, 2019; Slobodian et al., 2021).

Also unknown in the Brazilian scenario is information about the professor's profile in palaeontology teaching at the undergraduate level. UNESCO defines the teacher's profile as the competencies that include talents, skills, abilities, attitudes, and values put into practice in the classroom to teach students to build their knowledge and competencies to act in the labour environment (Butcher, 2019).

Given the above, we sought to answer the following guiding questions in this study: 1) What are the characteristics of the teaching profession in relation to palaeontology in Brazilian undergraduate courses? 2) How are the profile of palaeontology professors and the curriculum related to the quality of teaching this science in the country? With that in mind, this study aimed to describe the profile of palaeontology teaching in undergraduate courses in Brazil.

METHODOLOGY

We opted for an exploratory and descriptive approach with a quantitative nature of data. The exploratory character of the study is understood as the ability of the methodology to provide greater familiarity with the research problem through the search for information in bibliographic references, interviews, and/or typical data collection instruments, aiming to make it more explicit or build hypotheses (Gil, 2010; Moreira, 2011). The descriptive

approach is the systematic collection of information, following stages of registration, description, analysis, and interpretation of complex phenomena from a social perspective without interfering with the facts (Moreira, 2011; Ramírez-Montoya et al., 2021).

As for the quantitative nature of the study, it is a type of approach that uses varied quantitative techniques and tools for collecting numerical data (Rodrigues, de Oliveira & dos Santos, 2021). We extracted data from physical or electronic questionnaires and forms applied to a sample group. The information collected is tabulated and grouped based on the results of different variables, treated by descriptive statistics and expressed in tables and graphs.

This type of methodology allows the researcher to know opinions and conceptions of large representative samples of specific social groups for the understanding of a given phenomenon and makes it possible to summarise numerical data in a clear and objective way, identifying patterns in an analysis of numerical relationships to validate or reject a hypothesis or describe population profiles (Fassinger & Morrow, 2013; Rodrigues, de Oliveira & dos Santos, 2021).

Instruments

For data collection, an online semi-structured questionnaire was applied based on the subjects' self-identification, prepared via *Google Forms* platform. The instrument was composed of 17 objective and discursive questions that explored the analysis units of the palaeontology professors' profile, emphasising the professors' geographical distribution, their formative aspects, the characteristics of their performance in the curriculum component under analysis, and issues related to the structure and teaching and learning process of palaeontology in Brazilian undergraduate courses. The collected data were stored in a *Microsoft Excel* database for further analysis.

Participants

The target population consisted of university professors (n=37) who met the requirements of actively teaching the subject of palaeontology in undergraduate courses, in the teaching degree and research degree modalities [T.N., *licenciatura* and *bacharelado*] of public and private colleges and universities in Brazil and having valid private and functional e-mail addresses.

Data collection procedures

For the surveys, the questionnaires were sent by e-mail, from November 2020 to March 2021, to 206 institutions that should indicate the professional responsible for the curriculum component of palaeontology. Alternatively, some inquiries were sent directly to the research coordinator's known network of palaeontologists. We got an 18% response rate based on 37 requests answered. Museums, research institutes, or other non-degree awarding organisations were not included.

Ethical aspects were met in the data collected through permission to use the information for academic purposes. For example, each participant who agreed to participate in the research received a link to the electronic questionnaire, including a Free and Informed Consent Form (TCLE) to be completed and signed/checked.

The study was developed as per the ethical principles disciplined by Resolution 466/2012 of the National Commission of Ethics in Research (CONEP; Brasil, 2012), and the research project was approved by the Research Ethics Committee (CEP), via Plataforma Brasil (Process N. 4.339.958/2020) (Brasil, 2022b).

Data analysis

For the objective questions, we used descriptive statistics to examine the frequency of responses to the research questions represented by the analysis categories, describing the items in tables and graphs through simple percentages. We analysed and coded the discursive questions by clusters of similar answers to determine their intentions in the research context and organised and tabulated the data into an Excel spreadsheet. The design of the semi-structured form allowed us to extract thematic categories related to (a) general characteristics, (b) teacher education, (c) teaching experience, (d) undergraduate courses, (e) curriculum, syllabus, and programme discussion meetings, (f) inter and multidisciplinary, and (g) curriculum.

RESULTS AND ANALYSIS

Palaeontology, a higher education subject, has its own identity in academia (Schwanke & Silva, 2010). However, we question whether the essential characteristics of the teaching profile and the format of the palaeontological curriculum component effectively guarantee palaeontological education in the university environment in a pleasant, easy-to-understand, and

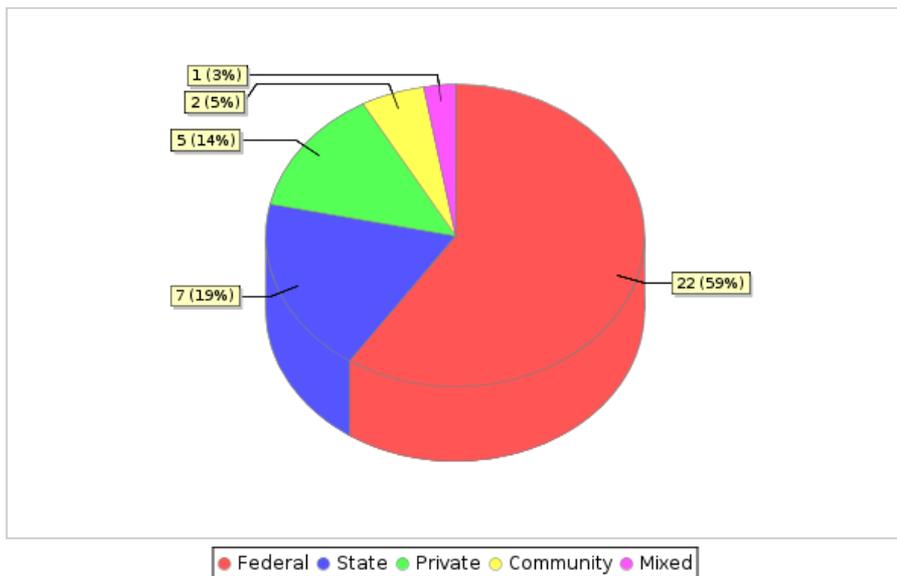
stimulating way. In this study, we discuss some related aspects and present the leading research findings.

General Features

Most respondents reported working in public institutions (78%), followed by 14% of private ones (Fig. 1), both distributed in 17 of the 27 Brazilian states (Fig. 2) and most are concentrated in the South and Southeast regions of the country.

Figure 1

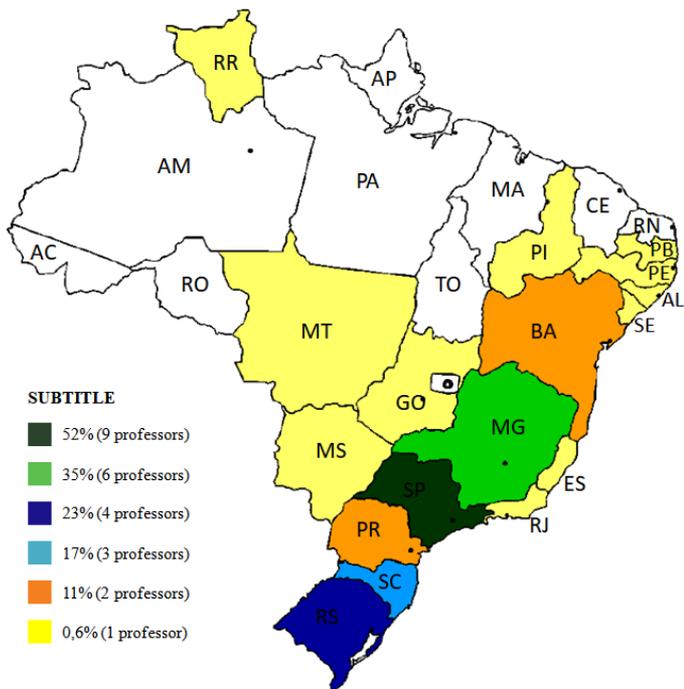
Classification of HEIs according to their administrative sphere (n=37), 2020-2021



Note: Mixed, refers to a municipal and private HEI.

Figure 2

Professors' distribution per Brazilian state (n=37), 2020-2021

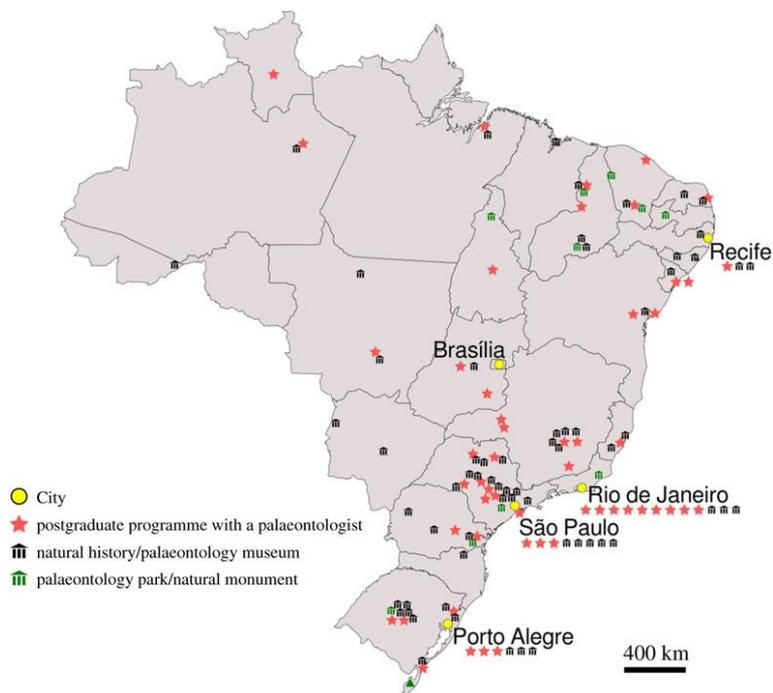


Our sample allows us to perceive that the professors participating in the research are, for the most part, from public universities. Our data agree to previous published national scientific literature (Back, 2019), making us believe it is crucial to problematise palaeontology teaching in this sphere of education.

Different studies have reported that, with few exceptions, teaching, structure, and conditions for learning palaeontology in public universities are far from expected (Diehl, 2014; Farias, 2017; Farias, Barros & Soares, 2017; Back, 2019), probably due to the ongoing national political crisis and the recent successive cuts in scientific investments in the country (Ernesto et al., 2018; Raja et al., 2022).

Figure 3

Distribution of palaeontological research centres in Brazil. (Cisneros et al., 2022)



As for the professors' geographic distribution, as mentioned above, they are concentrated mainly in the South and Southeast regions. Our results are confirmed as data from the literature show that there are currently 28 HEIs in the country that offer 44 Graduation Programs (GPs) with lines of research in palaeontology distributed in 13 Brazilian states (Cisneros et al., 2022). The states with the highest concentration of GPs in are South and Southeast regions of Brazil. São Paulo (27%) comes first and is followed by Rio de Janeiro (20.5%), Rio Grande do Sul (18.2%) and Minas Gerais (11.4%).

Currently, the South and Southeast traditionally offer the most jobs and research opportunities in the basic sciences. However, we believe that this scenario will soon change substantially, as the North and Northeast regions have received increasing incentives (Fig. 3) and many qualified professionals

have gained important positions for the development of palaeontology throughout the national territory (Kellner, 2015; Cisneros et al., 2022).

It was also possible to observe that only 34% of the respondents identified themselves as female, data that is corroborated when compared with information retrieved from the SBP, which shows that female palaeontologists correspond to 45% of its 713 associates (Kotzian & Ribeiro, 2009; Slobodian et al., 2021).

We observe that this reality is not exclusive to Brazil; it is also noticed in European countries. Studies show that female palaeontologists' participation in international congresses in the area corresponds to 43% of cases (Butler & Maidment, 2018). Women palaeontologists publish fewer articles and are less listed as first authors (Warnock et al., 2020; Plotnick, Stigall & Stefanescu, 2021), being frequently underrepresented in the field (Warnock et al., 2020). Different countries show that the rate of active women palaeontologists varies between 23 and 40% of cases (Rodríguez et al., 2020; Warnock et al., 2020; Plotnick, Stigall & Stefanescu, 2021), rarely reaching parity with men. Although women seem more prominent in palaeontology today, this is probably because there are more palaeontologists, but this does not mean that their relative proportion has increased (Warnock et al., 2020).

Therefore, the data suggest that we, as an academic community, urgently need to examine what drives the scenario in this direction. Therefore, we realise that there must be more data to understand better the barriers to women's career progression and where they need more support to stay in the field (Williams & Ceci, 2012; Plotnick, Stigall & Stefanescu, 2021).

Teaching formation

Most respondents have a degree in biological sciences (78%), followed by 19% from other undergraduate courses, such as geology, geography, oceanology and history. Our data are supported by comparison with the national scientific literature (Diehl, 2014; Siciliano, 2018). Resende and Rodrigues (2019), for example, found that 68% of SBP associates have a degree in the broad area of CBIO (science, biological sciences, environmental sciences, ecology, and zoology), 21% with training in the broad area of geoscience (geoscience, geology, geological sciences and geological engineering) and 11% in areas such as history, archaeology, medicine, museology, oceanography, and chemistry.

As for qualification at the graduate level, we found that most participants (68%) have a PhD, 11% have a master's degree, and 21% did not answer. Regarding the number of PhDs who teach palaeontology at the undergraduate level, although there are supporting data (Diehl, 2014) similar to ours, we believe neither represent the rest of the Brazilian population.

This is because, according to Resende and Rodrigues (2019), 82% of SBP associates have only a master's degree, concentrated in the area of geosciences (69%), in the large area of CBIO (25%), and other areas of knowledge (6%). Of the small number of individuals (18%) who have a PhD degree, 71% belong to the geosciences area, 24% to CBIO, and 5% to other areas.

Most participants (65%) have a postgraduate degree in geosciences (palaeontology), 22% of the palaeontology professors have specialisations in other areas of knowledge, and 11% of the participants did not answer.

The fact that 22% of professors are not specialists in the field is a reason for concern. For example, a previous study showed that CBIO students from Paraíba perceive the absence of specialist professors as a problem in learning palaeontological content (Farias, 2017; Farias, Barros & Soares, 2017); a phenomenon that is not exclusive to Paraíba.

For a change in scenario, we believe that Brazilian HEIs need more masters' degrees and PhD professors with specific training in palaeontology, in which geoscientific themes have been addressed in sufficient workload and depth to offer this professor a knowledge of the themes present in the subject curriculum (Farias, Barros & Soares, 2017; Santos, Bonito & Carneiro, 2017).

The low frequency of palaeontology specialist professors, the *academic palaeontologists*, does not happen only in Brazil. US researchers analysed the profile of academic palaeontologists in hundreds of HEIs and found that most of them employed only one palaeontologist in teaching, the typical *lone palaeontologist* (Flessa & Smith, 1998; Plotnick, 2008). It is estimated that there are about 1,000 US academic palaeontologists. In the Brazilian scenario, however, the number of palaeontologists who work as professors in our HEIs is unknown.

The benefits of the presence of palaeontology specialist professors go beyond the issue of mastering the content. It is associated with a greater possibility of links to research and extension projects and conditions/mediation for obtaining physical spaces (laboratories) and fossil didactic collections for practical classes (Farias, 2017).

Other fundamental characteristics that professors of palaeontology must present in the current educational scenario are the pedagogical competencies. The formation of academic palaeontologists must include specific subjects for teacher education, knowledge about methodological innovations in teaching in the field of palaeontology, and more effective pedagogical practices (Santos, Bonito & Carneiro, 2017). It is also necessary to know how to listen to the students, dialogue with their realities, and approach themes and new contextualised didactic proposals (Brazil, München & Schwanke, 2020; Martindale & Weiss, 2020; Hohemberger et al., 2021).

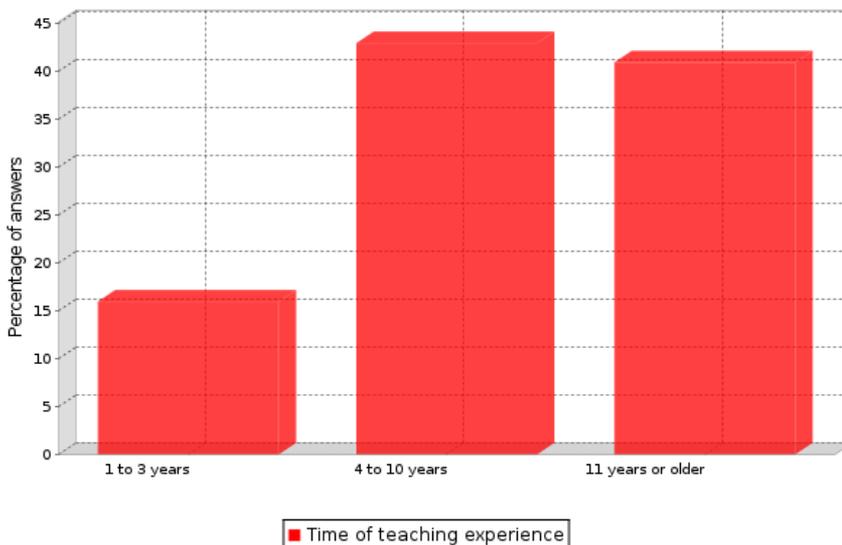
Therefore, we perceive that the culture of continuing education is important in higher education. Initial and continuing education are distinct but complementary processes (Cardoso, Araujo & Giroto, 2021). Continuing education is a method of professional and personal improvement that enriches professors' academic careers (Brasil & Schwanke, 2018; Kafer & Costa, 2020), as it starts from their experiences with real problems and helps them practically and theoretically in the activity (Cardoso, Araujo & Giroto, 2021). In palaeontology, in particular, it is necessary because some scientific concepts, besides technologies and methods of content delivery, change over time (Brasil & Schwanke, 2018). Therefore, professors must have access to such training, which must be included in university agendas to continuously improve undergraduate courses (Ramírez-Montoya et al., 2021).

Teaching experience

Eighty-four per cent of the respondents reported having four years or more experience teaching palaeontology. The remainder (16%) are less experienced (Fig. 4). Our sample allows us to perceive that the professors who participated in the research have teaching experience, which characterises them as experienced professionals (Corrêa & Pinheiro, 2016).

Figure 4

Professors' distribution per time of teaching experience (n=37), 2020-2021

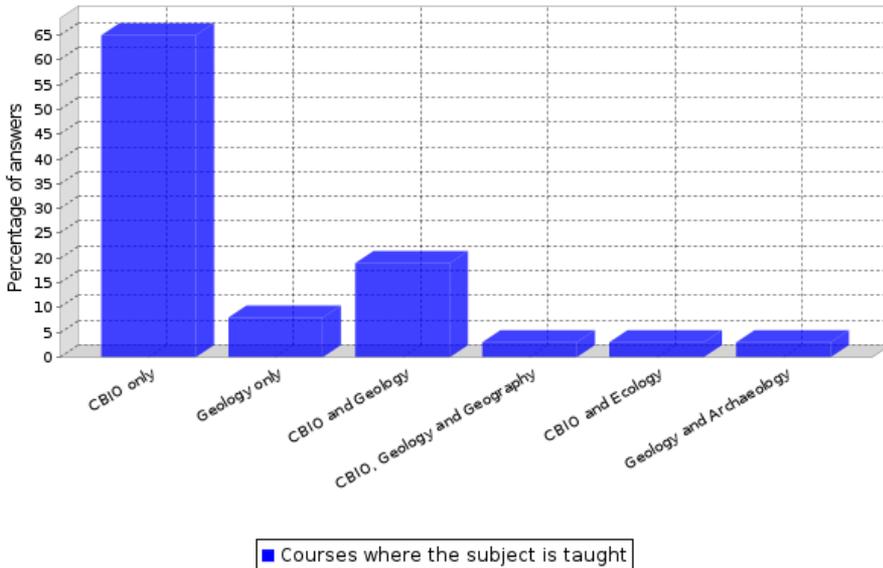


Undergraduate programmes

When asked about the course in which they teach palaeontology, approximately 90% of the participants stated, with the possibility of indicating more than one option per answer, that their classes are offered in the CBIO course, followed by 32% also in courses such as geology, ecology, geography, and/or archaeology (Fig. 5).

Figure 5

Professors' distribution per course where the subject is taught (n=37), 2020-2021



Our data also show that 27% of participants teach more than one undergraduate course. This is an item that deserves attention, since it may represent a scenario with few professors to impart a high number of classes, without time nor incentive for updating and academic research, in addition to leisure and rest hours being compromised by the accumulation of activities (Amorim, 2009; Carmo, Fleck & Santos, 2015; Elias & Navarro, 2019).

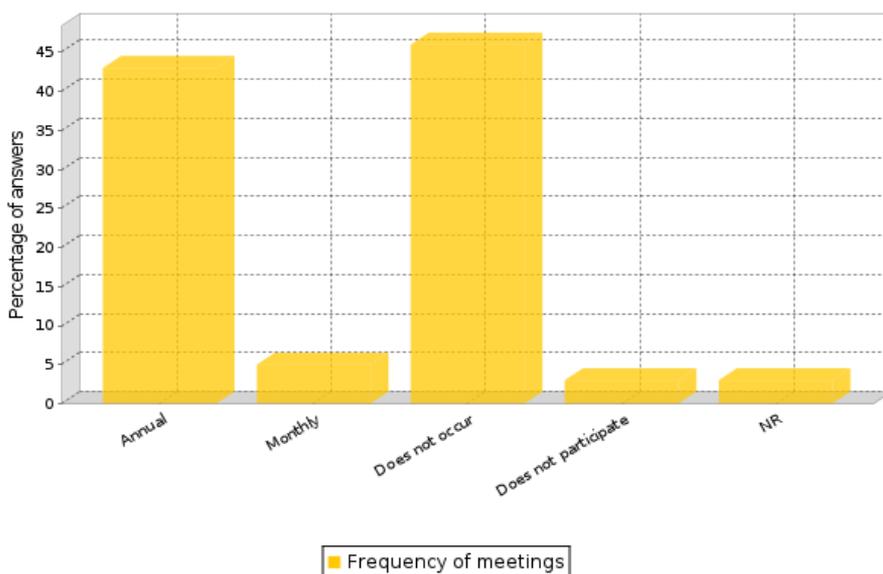
Curriculum, syllabus, and programme discussion meetings

Regarding meetings to discuss syllabuses, professors stated that they participate in meetings with an annual frequency of 43% and a monthly frequency of 5%, while approximately 50% of the rest reported not discussing in any way and frequency such issues with colleagues from other curriculum components, either because the pedagogical team does not promote such

gatherings or simply because they chose not to participate (Fig. 6). As for the discussion with peers about teaching methodologies, the professors stated that they participate in annual (51%) and monthly meetings (16%). However, sometimes these meetings do not occur (30%), and sometimes, they do not participate (3%).

Figure 6

Professors' distributions per frequency of meetings to discuss the syllabuses (n=37), 2020-2021



Note: NR, did not answer.

Around 50% of professors do not have the culture of often debating the syllabuses with their peers, and some do not discuss teaching methodologies (33%) usually applied in higher education. From our point of view, these data represent a problem in palaeontology teaching in the country, since we believe that discussion among colleagues is essential to understand *what* and *how* geoscientific content is taught in related subjects (Imbernon et al., 2020).

Inter and multidisciplinary

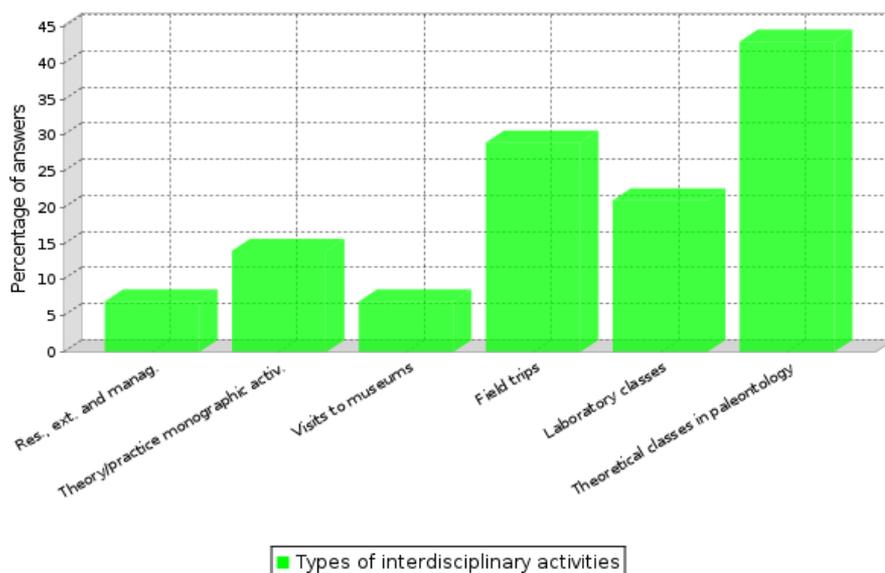
As for the practice of interdisciplinarity in the teaching of palaeontology (Fig. 7), professors stated, with the possibility of indicating more than one option per answer, that they group students from different subjects for the theoretical teaching of palaeontological issues (43%), followed by those who carry out interdisciplinary practices through field trips (29%), laboratory classes (21%), theoretical-practical monographic activity in the form of field reports or end-of-semester assignments (14%), visits to museums (7%) and those that carry out research, extension, and management activities (7%).

As for interdisciplinarity, it is known that the palaeontology curriculum component is interdisciplinary because it is at the intersection of a wide range of disciplines (Laflamme & Piunno, 2015). It is exactly because contemporary palaeontology is at the crossroads of interdisciplinary scientific research that professionals in their different fields of activity must know how to communicate so that both research and teaching work well.

An example of interdisciplinary teaching can be found in a study carried out in the state of Piauí, which developed a short course aimed at undergraduate students in mathematics and physics based on statistical applications for the analysis of fossil invertebrates (Nascimento & Gomes, 2020). Mathematical parameters were created for teaching biological diversity in different fossil subgroups. The results showed that before the short course, 90% of the participants did not know and could not define a fossil. Upon completion, 85% of them said the strategy is effective and encourages curiosity and critical thinking. Therefore, the study showed that the teaching of palaeontology should be directed not only to the geosciences but also to the exact sciences.

Figure 7

Professors' distribution per types of interdisciplinary activities (n=37), 2020-2021



Note: Res., ext. and manag., Research, extension and management.

Here, the result that calls our attention is that 30% of the professors associate interdisciplinary practices with field classes. The use of field trips together with other subjects makes it possible to develop in the student an integrative view of space and its processes (Silveira, Crestani & Frick, 2014; Silva & Campos, 2018). However, the term *interdisciplinarity* is sometimes misunderstood. Interdisciplinarity is a concept that seeks the intersection between the contents of two or more curriculum components or areas of knowledge, venturing into a dialogue with a different field to allow the student to develop a broader and more integrating vision of such themes (Pombo, 1994). Multidisciplinarity, in turn, is defined as a “set of juxtaposed subjects without any cooperation between them” (Pombo, 1994, p. 7). Confusion between these terms is common, but to really achieve interdisciplinarity in practical classes, we must develop a collective project that structures and

interconnects content from other related areas and directs the work carried out with students (Tessari et al., 2021).

It is also essential to emphasise that the science and biology teachers (in basic education) must work with geoscientific content in an interdisciplinary way, as proposed by the BNCC (Cruz, Moraes & Chaves, 2019; Silva et al., 2021; Costa & Scheid, 2022). Therefore, if these contents are not sufficiently studied during the degree course, future teachers will hardly present them to their students in basic education. Consequently, it will reduce the number of students interested in knowing, studying, and understanding the phenomena that govern and interfere with life on our planet.

Therefore, we propose that palaeontology professors develop classes and work together with other curriculum components (Silva & Hornik, 2011; Silva et al., 2021) and prepare and include proposals for extension services (Godoy et al., 2017; Pinheiro et al., 2021), since the literature points to the benefits of interdisciplinary and extra-class practices, especially at a time when knowledge is becoming increasingly fragmented and the workloads of palaeontology subjects are declining (Polinarski & Obara, 2018; UFES, 2008; UFRGS, 2018).

The curriculum

Credit hours of the subject

The vast majority (86.5%) of professors have a one-semester course, with a load between 40 and 96 class hours (average of 68 class hours), depending on whether the curriculum component is offered in isolation or combined with an introductory geology unit. On the other hand, only 13.5% of professors indicated that their disciplines are taught in two semesters, with at least 60 hours per semester.

For comparison purposes, the Federal Council of Biology (CFBio) issued opinion N. 01/2010 recommending a minimum workload of 90 hours to be completed for basic education in geology and palaeontology together for all biology courses in the country (CFBio, 2010). This represents 4.5% of the total course load.

Studies carried out in different regions of the country have shown that palaeontology, isolated or combined with geology, contains a workload that varies between 30 and 90 hours, with an average of 60 class hours; however, in

some cases, the time available for palaeontological contents is below the recommended by CFBio (Carrijo & Candeiro, 2010; Diehl, 2014; Farias, 2017; Farias, Barros & Soares, 2017; Back, 2019).

Research suggests that there is a tendency to combine palaeontological and geological components to reduce the total course workload (Carrijo & Candeiro, 2010; Back, 2019). Moreover, we verified that some subjects only present theoretical classes, ignoring the importance of practice for geoscience learning (Back, 2019). This issue deserves attention, as theory and practice must be related, and both must be worked together to promote meaningful learning.

Although our work does not intend to conclude whether the workload of palaeontology curriculum components offered by Brazilian undergraduate courses is sufficient or not to expose the essential contents provided in their syllabus, we propose that future studies analyse this issue. The national literature suggests that “the teaching of this science still does not receive the due importance, being deficient in all regions of the country” (Dantas & Araújo, 2006, p. 28).

Our data also show that about half (43.2%) of the palaeontology professors understand that a higher workload is necessary to present the basic content of the curriculum component. In comparison, practically the other half (56.8%) believe that the time they have is enough. There was no correlation between the undergraduate area and the perception of the time required for the subject. Both academic palaeontologists and specialists from other areas answered that the time is/ or is not enough within the varied total of hours.

The concern with the lack of time and the responsibility for choosing the subjects that will be part of the lesson planning has accompanied the teaching practice in palaeontology for decades (McKinney, 1972). On the other hand, we understand that increasing the number of hours alone does not solve the problem of application and contextualisation of contents. Thus, we believe it is necessary to review and adapt the curriculum to our times (Carrijo & Candeiro, 2010).

Bearing in mind that our sample is made up of experienced professors, it is interesting to highlight that the workload of around 60 hours per semester for palaeontology was not consensually considered low or insufficient. Currently, undergraduate courses are going through changes in their curriculum structure, as a few years ago (Brasil, 2018), the inclusion of extra-class activities, integration with extension services project, and elements of teaching

experience, this latter in the case of degree courses, in general, resulted in a greater number of objectives/tasks/disciplines in an unchanging total course workload.

This is a relatively recent movement, at least at the national level, and seems to be associated with changes in teaching and learning and the objectives of educational institutions, especially public universities. Many hours in the classroom, with non-dialectical expository classes lasting more than 40 minutes, do not necessarily imply the effectiveness of the teaching and learning process, especially in geosciences (Cerri et al., 2012; Figueiredo & Valois, 2017; Dolphin et al., 2018).

Optimising the use of time in classroom environments with practical activities or even topics of interest to the class using active teaching methodologies (Martindale & Weiss, 2020; Ozkaya de Juanas, Barroso-Barcenilla & Callapez, 2021) may be the best strategy for learning palaeontology. Although it is worth emphasising that we recognise the limitations associated with the overload of hours of teachers' activities and issues related to the disposition, study, and preparation for the choice and application of practical activities in the classroom (Tsuzuki, Turke & Maistro, 2017). However, managing examples and practices in this direction may prove more effective and/or easier to apply when you have more than one semester with the same class.

Given the points above, we suggest that geosciences, including the palaeontological curriculum component, be presented in the CBIO curriculum for at least one year, regardless of the type of course (teaching degree or research degree). Faced with the difficulties of teaching a historical and complex science, when we approach the content for a prolonged period, the professor will have the opportunity to be more effective in teaching. Working over a year, we suggest that the professor, when starting the subject, apply a survey questionnaire. We believe that this strategy should become part of the culture of teaching palaeontology in the university environment since, in this way, the professor may perceive what geoscientific knowledge the class brings as baggage and what interests they may have in common (Duarte et al., 2019). This diagnosis can guide the teacher's actions throughout the year of work with the class.

Requirements

Approximately half of the respondents (54.1%) reported that palaeontology does not have prerequisites. However, 35% of professors think students should take at least “Introduction to Geology” before starting the palaeontological contents. One report, in particular, suggested that this geological content could be taught concurrently with palaeontology. Another interviewee mentions that the presence or absence of a prerequisite should be based on the graduate’s profile and the contents taught in the palaeontological curriculum unit.

Furthermore, when asked whether there would be a subject that should be considered a prerequisite for teaching palaeontology, at least 57% of respondents mentioned geology. In turn, 43% of participants either did not answer or only mentioned that prerequisites are useless.

As half of the respondents (57%) consider essential an introduction to the basic concepts of geology, this led us to consider that the CBIO course does not have any other mandatory curriculum component that works with geoscience content. Therefore, it is essential that the precepts of geology or geosciences be presented to students before/or at the beginning of the palaeontology subject.

We understand that the historical view of geosciences is essential for teaching not only palaeontology but all aspects related to the evolution of life (the central theme of the CBIO course). If we take into account that the core contents of geosciences are seldom addressed in basic education (Cruz, Moraes & Chaves, 2019; Teixeira, Machado & Zafalon, 2021), especially in the final years, it is imperative that colleges “resume” these subjects before presenting palaeontology.

Contents

When asked about the level of detail with which certain paleontological contents were taught in the classroom, most teachers pointed out, among the predetermined topics, and with the possibility of indicating more than one option per answer, that the themes *Geological time* (95%), *Extinctions* (87%), *Principles of stratigraphy* (84%), *Palaeoenvironments* (70%), *Dating methods* (65%) and *Microfossils* (57%) were addressed sufficiently or in a very detailed way in the subject (Tab. 1). As for the geological eras, we also perceived that most professors considered the themes *Precambrian*, *Paleozoic*, *Mesozoic* and

Cenozoic as having a sufficient or well-detailed approach in 81%, 84%, 84% and 78% of cases, respectively.

On the other hand, most professors reported little or non-existent approaches to themes such as *Description of rock cycles* (67%) and *Brazilian legislation related to natural heritage* (60%) in the classroom.

Table 1

Approach level of palaeontological content in the classroom (n=37), 2020-2021

Contents	Level of approach							
	It is not addressed		Superficial		Sufficient		Very detailed	
	N	%	N	%	N	%	N	%
Geologic time	-	-	2	5	13	35	22	60
Principles of stratigraphy	-	-	8	22	22	59	7	19
Dating methods	1	3	12	32	18	49	6	16
Description and cycles of rocks	9	24	16	43	8	22	4	11
Palaeoenvironments	1	3	10	27	20	54	6	16
Extinctions	-	-	5	13	15	41	17	46
Microfossils	1	3	15	41	15	41	6	16
Precambrian (geology and biology)	1	3	6	16	16	43	14	38
Palaeozoic (geology and biology)	1	3	5	13	14	38	17	46
Mesozoic (geology and biology)	1	3	5	13	14	38	17	46
Cenozoic (geology and biology)	2	5	6	16	13	35	16	43
Brazilian legislation related to natural heritage	8	22	14	38	12	32	3	8

To a more successful higher education palaeontology teaching that contributes to the dissemination of palaeontology throughout the country, we must point out two other aspects for a more detailed discussion:

First, we believe it is fundamental for the palaeontological community to discuss and point out which contents must appear in the curricula. There are currently no discussions that better direct palaeontology teaching professionals. Inevitably, teachers end up following the structure available in books to teach their classes. As not all palaeontology professors have graduate-level training in this area, it is necessary to have guidance from specialists to assist those who may have to teach classes in this content.

The contents identified as being sufficiently worked on in the classroom are varied (Table 1), but more contextualised ones, such as the theme of *Brazilian legislation related to natural heritage*, are not commonly discussed. In view of all the recent actions by the SBP about the custody of national fossils and the influence of social networks to strengthen national science (Lenharo & Rodrigues, 2022), palaeontology professors must address such matters in class and more, address them to relate them to the daily lives of students, motivating them to learn a contextualised palaeontology (McConnell et al., 2018). An increasing number of researches in geoscience teaching have shown that *affection* is a significant factor in the construction of knowledge (Piranha & Carneiro, 2009; Compiani, 2011). In this sense, bringing up topics that interest students and that are being debated in the media is one of the ways to create engagement with the subject.

In our research, we identified that the most complex topic to be presented to students was *deep time*. This is one of the central themes of geosciences (Cervato & Frodeman, 2013), and many publications address questions about teaching this concept (Catley & Novick, 2009; Dodick & Orion, 2003a, 2003b). One of the aspects related to it (the teaching of deep time) is the ability to visualise the geological structure in the field. This means that field activities are mandatory in geoscience teaching and, in particular, understanding deep time. Developing capabilities for three-dimensional visualisation of structures, the diachronic and retrodictive thinking are essential for geoscientific teaching. Therefore, our second point to be considered is that palaeontology activities should always be linked to field and laboratory activities to enable the student to develop specific skills in geosciences (King, 2008).

Current and past teaching strategies

When asked to compare the classes they currently teach as professors with those they received as students, relevant aspects were mentioned. Twenty-four per cent of respondents see similarities in the teaching methods employed in both realities, ranging from traditional expository and evaluative methods in theoretical classes to more dynamic and interactive classes that use pedagogical teaching resources to bring fossils close to the students' reality.

In addition, 22% of respondents report similar experiences between the palaeontology contents of both realities, mentioning that they still use much of the same old syllabi in their classes, which indicates that the structure of the discipline has been maintained over time. According to the participants themselves, the reason for this is that geological time follows a consecrated and logical line. Furthermore, 16% understand that practical classes are similar in both realities, laboratories and field trips.

On the other hand, when questioned about the existing differences between the palaeontology classes they currently teach and those they attended as students, 30% of respondents indicate that there are now more methodological innovations and didactic resources available for engagement and learning of abstract concepts and more didactic resources (14%) for practical classes. Among the negative aspects, the current low number of field trips (11%) stands out.

We realised that the fact that professors now have available methodological innovations and didactic resources, and more fossil material for laboratory classes is a positive point for the permanence of practical classes. Through contact with real fossils and/or replicas, it is possible to get closer to the objects, whether in physical environments (classrooms) or non-formal learning environments (museums).

However, field trips have been reduced for several reasons: lack of institutional funding, professors' lack of time and apparent students' lack of motivation. On the other hand, if well planned, a field trip can clarify several classroom aspects and that students have difficulty perceiving just by looking at photos, looking at decontextualised samples or listening and reading the theory (Compiani, 2011; Silva, Santos & Gertrudes, 2015). Studying the environment also brings aspects of belonging and affection, which help students understand the complexity of geological phenomena and the non-utilitarian view of the planet (Pirinha & Carneiro, 2009; Compiani, 2011).

We propose that the palaeontology teacher use virtual field trips (Souza & Ribeiro, 2021) if the outcrops are far from the study sites or there are no financial resources for face-to-face visits (Shinneman, Loeffler & Myrbo, 2020). Those strategies have been increasingly explored in undergraduate courses at the national and international levels, especially after the adoption of emergency remote teaching during the Covid-19 pandemic (Souza & Ribeiro, 2021; Jones & Washko, 2022).

FINAL CONSIDERATIONS

The analysis of the reports shows, preliminarily, that there are still many difficulties and challenges to be overcome to raise the quality of undergraduate palaeontology teaching throughout the country, especially when considering the following issues raised from the perceptions of the subjects involved:

- a) a minority of female professors;
- b) low coverage of postgraduate professors in palaeontology for the North, Northeast and Midwest regions;
- c) a portion of the palaeontology professors are specialists in other fields of study not related to it, which can result, when not directed, in instrumental and conceptual deficiencies that will impact the quality of the teaching and learning process of paleontological contents;
- d) approximately a quarter of the professors teach the curricular component in two or more undergraduate courses, which allows us to infer that not only our sample but also other palaeontology instructors in the rest of the country face extensive working hours that bring losses related to the lack of time for leisure and rest;
- e) most professors do not promote interdisciplinary practices in their subjects, and half of them do not participate in departmental meetings to discuss the syllabi with their peers;
- f) most professors must teach the essential contents foreseen in the planning in a short course of only one semester, and about half of the study participants feel that the workload is insufficient for teaching so many complex subjects;

g) most teachers report a low or non-existent approach to topics such as *Description of the rock cycle* and *Brazilian legislation related to natural heritage* in the classroom.

Our data also indicate that most palaeontology professors have elementary education in CBIO and teach in courses in the biological area, which suggests, when combined with data available in the literature, that biological sciences courses play a role in maintaining the teaching of palaeontology in the national territory.

Regarding the implications of this study, we recommend that the new generation of students who intend to start a postgraduate course in palaeontology should receive realistic information about career prospects in academia and be aware of alternative employment paths (Butler & Maidment, 2018).

The limitations of the study involve a small sample restricted to regional patterns. In addition, the detailed analysis categories – (a) general characteristics, (b) teacher education, (c) teaching experience, (d) undergraduate courses, (e) curriculum, syllabus, and program discussion meetings, (f) inter and multidisciplinary, and (g) curriculum – do not cover all the essential topics for the knowledge of the teaching profile of palaeontology that recent research has shown to be essential to support the maintenance of the quality of teaching and learning of this science.

On the other hand, we recognise the importance of this study. The results presented can provide a valuable basis for defining goals, objectives, and contents in continuing education programmes to update the teacher education curriculum and support the reform of palaeontology teaching in Brazilian undergraduate courses in higher education institutions. Our data can also help the processes involved in training students for life and work and be used as a guide for further research on this topic, which is still little explored in the international scientific literature.

Suggestions for future studies include the analysis of professors per academic levels or categories (assistant, associate, adjunct, emeritus, professor, visitor), professors' area of specialisation, the period in which the subjects are located in the course curriculum, number of academic palaeontologists employed by departments (biology, zoology, botany, anatomy), and analysis of stability or growth of academic palaeontologist positions per decades.

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AUTHORSHIP CONTRIBUTION STATEMENT

This article was prepared and organised by three authors. EFA was responsible for building the theoretical and methodological contributions and the description, analysis, and discussion of the data. DLT collected the data and analysed it in a preliminary way. CZ conceived the idea, guided, and supervised the project, discussed, revised, and corrected the analyses and the writing of the article.

DATA AVAILABILITY STATEMENT

The data supporting the results of this study will be made available by the corresponding author, EFA, upon reasonable request.

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