ACTA SCIENTIAE

ISSN: 2178-7727
DOI: 10.64856/acta.scientiae.8681

Didactic Guide for the Appropriation of Knowledge About Fossils of the Fourth Colony Geopark, RS-Brazil

Rosemar de Fátima Vestena[a]
Daiane de Paula Pentiado Felício[a]
Alana Rodrigues Rigão Achterberg[a]
Mariana Sarturi Hundertmarck[a]
Clara Maria da Silva Vasconcelos[b]

a. Programa de Pós-graduação em Ensino de Ciências e Matemática (PPGECIMAT), Universidade Franciscana (UFN), Santa Maria, RS, Brasil.
b. Departamento de Geociências e Ordenamento do território, Universidade do Porto, Porto, PT.

ABSTRACT

Background: Study visits to sites that preserve fossil collections provide concrete learning experiences for science teaching and learning. **Objective:** To analyse how the use of a didactic guide, prepared to guide study visits to the Paleontological Research Support Center (CAPPA), can promote the appropriation of knowledge about fossils in the territory of the Fourth Colony Geopark. **Study design:** The study adopted a qualitative and documentary approach. **Setting and participants:** twenty Year 5 primary school students of a public school in the vicinity of the Quarta Colônia Geoparque (QCG). **Data collection and analysis:** For data collection, the Didactic Guide for Visits to CAPPA was applied, consisting of 30 questions applied to a class of the 5th year of Elementary School, formed by 20 students, with 14 students participating in the research, about 11 years of age from a public school in the central region of Rio Grande do Sul (Brazil). The data were analyzed using the content analysis technique. **Results:** The findings showed that students' knowledge of fossils largely derives from extracurricular contexts and is strongly influenced by the media, which generally do not address fossils from the QCG territory. **Conclusions:** Study visits to CAPPA proved to be an effective teaching strategy to promote the study of the fossil heritage of the territory of the Quarta Colônia Geoparque. The study highlights the potential of the didactic guide as an instrument of pedagogical mediation to organize study visits and promote the appropriation of scientific knowledge in non-formal science education settings.

Keywords: dinosaurs; research centers; study visits; geopark.

Corresponding author: Rosemar de Fátima Vestena. Email: rosemar@ufn.edu.br

Guia Didático Para a Apropriação de Conhecimentos Sobre Fósseis do Quarta Colônia Geoparque, RS-Brasil

RESUMO

Contexto: Visitas de estudos a locais que preservam acervos fossilíferos configuram-se como experiências concretas para o ensino e a aprendizagem de Ciências. **Objetivo:** analisar como a utilização de um guia didático, elaborado para orientar visitas de estudos ao Centro de Apoio à Pesquisa Paleontológica (CAPPA), pode promover a apropriação de conhecimentos acerca dos fósseis do território do Quarta Colônia Geoparque. **Desenho do estudo:** a pesquisa é de abordagem qualitativa e documental. **Ambiente e participantes**: vinte estudantes do 5º ano do Ensino Fundamental de uma escola pública nas proximidades do Quarta Colônia Geoparque (QCG). **Coleta e análise dos dados**: Para a coleta de dados, foi aplicado o *Guia Didático para Visitas de Estudos ao CAPPA*, composto de 30 questões aplicadas junto a uma turma do 5º ano do Ensino Fundamental, formada por 20 estudantes, com 14 estudantes participantes da pesquisa, com cerca de 11 anos de idade de uma escola pública da região central do Rio Grande do Sul (Brasil). Os dados foram analisados por meio da técnica de análise de conteúdo. **Resultados**: Constatou-se que os conhecimentos dos estudantes acerca de fósseis são advindos de contextos extraescolares com forte influência da mídia que, geralmente não abordam fósseis do território do QCG. **Conclusões**: As visitas de estudo ao CAPPA revelaram-se uma estratégia didática eficiente para promover o estudo do patrimônio fossilífero do território do Quarta Colônia Geoparque. O estudo evidencia o potencial do guia didático como instrumento de mediação pedagógica para organizar visitas de estudo e promover a apropriação de conhecimentos científicos em espaços não formais de educação científica.

Palavras-chave: dinossauros; centros de pesquisa; visitas de estudo; geoparque.

INTRODUCTION

Curiosity about dinosaurs is a phenomenon widely observed in everyday social life and, consequently, present in the school environment, whether through the media or other resources. In this context, learning about the Earth and the Universe and, more specifically, about fossils has sparked growing interest among students, although the topic is usually addressed in schools is usually limited to the classroom setting. In official Brazilian education documents, fossils are mentioned only briefly and sporadically.

Fossils are the remains of living organisms or their biological activities, preserved in various materials over time. Although preservation occurs mainly in rocks, it can also take place in sediments, ice, resins, and other media. These remains are fundamental for dating and reconstructing the planet's geological history. According to Zucon (2011), paleontology, as a science, seeks to provide

insights into the biological evolution of organisms over time, with fossils conceived as true "documents" that record pivotal moments in the history of life on Earth.

Both Izaguirry *et al*. (2014) and Brazil (2018) emphasise that educational initiatives are essential for promoting understanding and appreciation of palaeontological heritage. These initiatives can and should be incorporated into science teaching. In this context, knowledge of fossils can be a valuable resource in the teaching and learning process, including by helping to dispel common misconceptions among students. It should also be emphasised that the subject deserves to be explored in greater depth and debated, not only because of students' interest, but above all because of its relevance to understanding the processes that have shaped the history of the Earth and, therefore, to developing a broader perspective on the existence of life and other phenomena that have occurred and continue to occur on the planet.

Visits to museums and research centres, when accompanied by appropriate educational organisation such as the use of guides designed to explore spaces dedicated to the dissemination of geosciences constitute a relevant and enriching practice for the development of students' scientific thinking. In this regard, the Quarta Colônia Geopark (QCG), through the Centre for Palaeontological Research Support (CAPPA), is dedicated not only to the collection, study and preparation of fossil finds from the region, but also to scientific outreach, organising guided tours of its collection.

However, when it comes to students, it is vital to link this learning experience to the school curriculum. Thus, effective pedagogical organisation is therefore essential. It is recommended that planning includes structured stages of the field trip, as proposed by Orion (1993): Pre-Visit (preparation at school), Visit (on-site experience) and Post-Visit (consolidation of knowledge). From this perspective, the use of a study guide to guide the process is a relevant strategy.

Furthermore, teaching about fossils can be enhanced when carried out in contexts outside the classroom, such as museums, parks, geoparks and science centres, enabling a more accurate and meaningful understanding of the subject.

Although studies highlight the pedagogical potential of field trips and recognise the importance of non-formal settings for science education, there is still a scarcity of research analysing how a structured teaching guide can pedagogically organise the Pre-Visit, Visit and Post-Visit stages, thereby

facilitating students' acquisition of scientific knowledge. In this context, this study seeks to answer the following research question: *How does a structured teaching guide for field trips to the Centre for Palaeontological Research Support (CAPPA) contribute to primary school students' acquisition of scientific knowledge about the fossils of the Quarta Colônia Geopark?*

In light of the above, the aim of this study is to analyse how the use of an educational guide, designed to facilitate field trips to the Centre for Palaeontological Research Support (CAPPA/UFSM), can promote the acquisition of knowledge about the fossils found within the Quarta Colônia Geopark.

This study contributes by demonstrating that a structured educational guide can act as a tool for mediating and organising field trips pedagogically, supporting lesson planning, systematising pre-visit, visit and post-visit activities, and facilitating students' acquisition of scientific knowledge.

THE FOSSILS OF THE QUARTA COLÔNIA GEOPARK AND CAPPA.

Geoheritage sites provide valuable settings for geoscience education by enabling learners to engage directly with geological features and processes. Such experiences can reinforce concepts introduced in the classroom while fostering curiosity and interest in the Earth sciences. By connecting formal education with non-formal and informal learning contexts, these sites can contribute significantly to the development of geoscience literacy and greater environmental awareness. Moreover, learning in outdoor environments encourages students to recognise the Earth as an interconnected system and to develop a more integrated understanding of the relationships among its different components (Vasconcelos & Ribeiro, 2025).

The Quarta Colônia Geopark (QCG) stands out for its remarkable palaeontological wealth, as evidenced by the diversity and significance of the fossils identified. Most of these specimens are vertebrates, amongst which dinosaur species from the Triassic Period are particularly notable. Furthermore, fossils of other prehistoric groups of great evolutionary importance have been identified, such as dicynodonts, rhynchosaurs, cynodonts and pseudosuchians, establishing the area as a strategic site for research into the life and evolution of reptiles during the Mesozoic Era (Godoy *et al*., 2012).

The main palaeontological finds in the QCG are concentrated in the municipalities of Agudo and São João do Polêsine. In 2021, Guinness World Records recognised that the world's oldest dinosaurs may have inhabited the

area that today comprises part of the central region of the state of Rio Grande do Sul, based on fossils from Quarta Colônia (Beck & Lopes, 2021). In the municipality of Agudo, four species of dinosaur have been identified: Pampadromaeus barberenai (Cabreira *et al*., 2011), *Bagualosaurus agudoensis* (Pretto *et al.,*2018), *Macrocollum itaquii* (Müller *et al*., 2018) and *Erythrovenator jacuiensis* (Müller, 2023). In São João do Polêsine, the species *Buriolestes schultzi* (Cabreira *et al*., 2016) and *Gnathovorax cabreirai* (Pacheco *et al.*, 2019) have been recorded.

It is essential to emphasise that the QCG's Palaeontological Heritage is of global significance for understanding the evolution of life. As Rosa (2018, p. 107) argues, "the importance of southern Brazil's palaeontological heritage is not limited to that territory, but has global significance, given that many of its fossils represent key elements for understanding geological changes and the evolution of life on our planet". The sedimentary rocks of the QCG, deposited between 233 and 225 million years ago (the Triassic Period of the Mesozoic Era), provided favourable conditions for the fossilisation process. The fossilisation of the QCG dinosaurs occurred mainly through permineralisation, a process in which buried bones are infiltrated by mineral-rich groundwater, which fills their internal spaces, hardens and gradually transforms the bone material into rock (Pretto, 2021; Anelli *et al*., 2020).

The Centre for Palaeontological Research Support of the Federal University of Santa Maria (CAPPA/UFSM) was opened in 2013 and is affiliated with the Centre for Natural and Exact Sciences at UFSM. It is a public research institution with facilities comprising classrooms, an administration office, a fossil preparation laboratory equipped with specialist instruments, a foyer for scientific exhibitions and a a visitor reception area area, a technical storage room for the scientific collection, and accommodation for researchers. CAPPA also possesses field materials and equipment, prospecting tools and stereoscopic magnifiers for analysing the collected material.

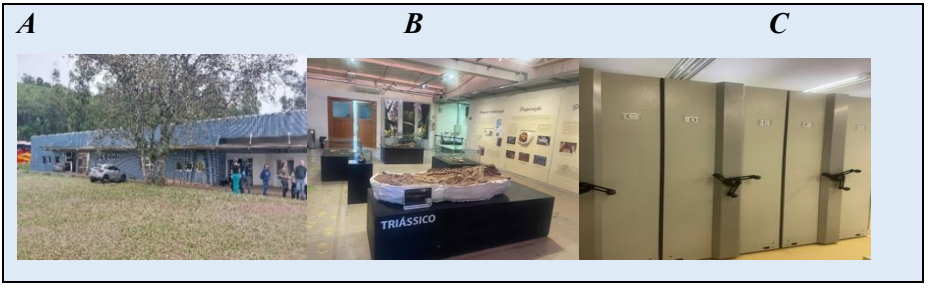
CAPPA currently has a team of fifteen members, working at different stages of the scientific process: fieldwork, excavation, fossil preparation and conservation, laboratory analysis, collection cataloguing procedures, three-dimensional (3D) printing and the production of replicas for exhibition purposes. Among these professionals, three are research lecturers at UFSM, whilst the others are postgraduate students affiliated with the institution. The Centre's mission involves mapping new fossil sites, monitoring already known areas, collecting and preserving vertebrate and plant fossils, as well as supporting research in palaeontology and geology and promoting scientific

outreach (CAPPA/UFSM, 2023). Research activities focus primarily on the study of fossils from the Triassic Period, dating from between 250 and 225 million years ago (Franco *et al*., 2021).

Although not formally classified as a museum, CAPPA maintains a permanent exhibition of fossils open to the public, serving as an important venue for scientific outreach aimed at researchers, schools and visitors in general. Visitors are welcomed by palaeontologists or trained guides, who facilitate the experience. The exhibition includes original fossils and replicas (Figure 1) from the QCG territory and covers the fundamentals of palaeontology and evolution. According to administrative data from CAPPA/UFSM, the centre receives an average of 600 visitors per month, including tourists, students and teachers from different levels of education, reaffirming its role as a strategic centre for the popularisation of science and the promotion of the region's palaeontological heritage. Figure 1 shows illustrative images of this infrastructure (A, B and C).

Figure 1

Sections of CAPPA: (A) Main Building, (B) Fossil Exhibition Room and (C) Burial Room. Own photographs.



Among the exhibits are the first complete dinosaurs discovered in Brazil (Müller *et al.,* 2018; Pacheco *et al*., 2019), some of the world's oldest dinosaurs (Cabreira et al., 2016), precursors of pterosaurs and mammals (Kerber *et al*., 2022; Müller *et al.,* 2023) and representatives of the basal crocodylomorph lineage (Barberena, 1978; Müller *et al.,* 2020). The first fossil listed by CAPPA was *Macrocollum itaquii*, a primitive sauropodomorph dinosaur from the late Triassic (between 201 and 237 million years ago), considered one of the oldest representatives of this group (Brusatte, 2019). Due to its scientific significance and the fact that it constitutes the holotype of the species that is, the reference specimen on which the taxon is based this

specimen is kept in the collection storage room (C) and is not on permanent display. What is presented to the public are the paratypes and replicas (B), which enable the exploration of themes such as deep time, the geological timescale and the evolution of dinosaurs (CAPPA/UFSM, 2024). Table 1 presents the fossils currently on display at CAPPA, detailing information such as scientific identification and characteristics. This systematic organisation of the collection not only demonstrates the palaeontological diversity available for visitors to view, but also highlights the preservation processes and science communication practices employed.

Table 1

Fossils on display at CAPPA.

Scientific name	Features and information	Image
Venetoraptor gassenae	Measuring around 1 metre in length and weighing between 4 and 8 kilograms. It had a raptorial beak and proportionally large forelimbs with long, sharp claws for handling prey or climbing trees. The reptile lived around 230 million years ago and belongs to an extinct group known as the *Lagerpetidae*. They are considered close relatives of the pterosaurs, the flying reptiles that shared the Earth with the dinosaurs. However, they were not capable of flight.	
Exaeretodon riograndensis	It was a cynodont and one of the largest traversodontids; it is among the many vertebrate fossils – including dinosaurs and other cynodonts – that have been discovered, which gives the QCG international scientific significance. They were herbivores or omnivores characterised by transversely broad upper post-canine teeth. They could reach up to 1.8 metres in length.	

Bagualosaurus agudoensis	It was a small basal dinosaur, measuring around 1.5 metres in length and weighing between 7 and 10 kg. It had a slender, agile body, with long hind limbs adapted for bipedal locomotion. Its forelimbs were smaller but functional, with sharp claws. The skull was small and elongated, with curved, slightly serrated teeth, suggesting an omnivorous or carnivorous diet. The long tail helped with balance when moving quickly.	
Buriolestes schultzi	The skeleton is not yet completely known. The species was described on the basis of a very well-preserved partial skeleton. Shortly afterwards, a second, even more complete skeleton was announced. However, even when all the elements are brought together, there are still a few parts of the skeleton that are not well understood. It was about 1.5 metres long, weighed six kilograms and walked on its two hind legs.	
Dynamosuchus Collisensis	Measuring around 2 metres in length, this animal walked on all fours most of the time, but was capable of standing upright at times. Its jaws were equipped with large, serrated, dagger-shaped teeth, suggesting that it was a carnivore.	
Trucidocynodon riograndensis	From the Latin ‘trucido’, meaning ‘one that kills cruelly’ due to its specialisation in carnivory; and ‘cynodon’, which relates to the group to which it belongs, Cynodontia. The species name ‘riograndensis’, meanwhile, refers to the state of Rio Grande do Sul, where the species was found.	
Prestosuchus chiniquensis	*Prestosuchus* is the largest predator ever to have inhabited the state of Rio Grande do Sul, and during its time it was among the largest predators in the world. *Prestosuchus* was a quadrupedal	

	carnivore. It is at the root of a lineage known as Loricata, which would go on to give rise to today's alligators and crocodiles.	

According to Viana & Carvalho (2019, p. 80), "the identification of dinosaur fossils requires detailed studies involving taxonomy and phylogenetic systematics, as well as complementary analyses such as morphometry, scanning electron microscopy, energy-dispersive spectroscopy, electron microprobe analysis and computed tomography". Thus, each fossil species discovered by researchers is given its scientific name in accordance with the principles of binomial nomenclature (the formal recording of species), whilst also recognising the historical and cultural significance associated with palaeontological discoveries (CAPPA/UFSM, 2025).

With this in mind, researchers at CAPPA have sought to honour the discoverer, the collection site or the family that owns the geosite, and have named species after the locations where the fossils were found or after members of the local community. One example is the dinosaur *Venetoraptor gassenae*, discovered in the municipality of São João do Polêsine in 2022 by the palaeontologist Rodrigo Temp Müller (CAPPA/UFSM). The genus name, *Venetoraptor,* means 'raptor of Vale Vêneto', in reference to the tourist destination of the same name located in the municipality. The specific epithet, *gassenae*, pays tribute to Valserina Maria Bulegon Gassen, one of the key figures behind the creation of the QCG Centre for Palaeontological Research Support (CAPPA/UFSM, 2025).

STUDY VISITS AND EDUCATIONAL ORGANISATION

A field trip can be characterised as an active methodology in which the student takes the lead in their own learning process, as it enables the development of investigative skills within the new environment, allowing them to explore the study site directly and comprehensively (Yemini *et al.,* 2023). In activities carried out outside the school environment, the teacher acts as a facilitator of learning, enabling students to self-regulate throughout the process (Heyde & Doyle, 2022; Yemini *et al*., 2023). According to Yemini *et al.* (2023), the main objectives of a field trip are: to develop conceptual knowledge; to foster interest in and motivation for science; to promote positive attitudes towards science; to encourage careers in science; to make use of available local and cultural resources; to strengthen the teacher–pupil relationship; and to promote positive and meaningful changes in the learning environment.

According to Pessoa (1991), during the visit, an activity guide should be carefully designed to guide students in carrying out practical tasks, and should be designed on the basis of the objectives and information relevant to the visit. The activities designed for students may include various types of exercises, allowing answers to be recorded directly in the document itself, in spaces set aside for responses (Gomes *et al.,* 2020). An activity guide can also be used as a tool for pedagogical mediation, promoting students' engagement with cultural and natural heritage, as well as encouraging observation, recording and reflection on the sites visited.

According to Pessoa (1991) and Orion (1993), at the end of the study visit, the activities and responses recorded in the guide should be assessed. The document may contain specific questions to be addressed on site, serving as a complement to the visit. However, in the context of a study visit, it is essential to have a plan that takes into account both school management and pedagogical considerations. Orion (1993) proposed an Organisational Model for a field trip – adapted here for study visits – structured in three phases: Preparation Phase (Pre-Visit), Visit, and Synthesis Phase (Post-Visit).

The pre-visit involves preparing for the field trip, with the aim of familiarising students with the topic; this may include laboratory activities that simulate processes observed in the field. This phase aims to minimise the so-called 'novelty gap' as much as possible, creating a solid foundation of prior learning. Conducting preliminary studies of the site helps to engage students and raise their awareness of the visit's objectives, enabling richer connections to be made between the content covered in the classroom and the experiences encountered in the real environment (Pessoa, 1991). During the next phase, the Visit, the teacher should prepare supporting materials, such as a guide, to direct the students and encourage their interaction with the environment or subject of study. In the Post-visit phase, usually carried out in the classroom, students are asked to deepen, consolidate and systematise the knowledge gained from the field experience (Orion, 1993).

Accordingly, the sequence presented in this paper for the CAPPA Field Trip Guide, at the Quarta Colônia Geopark, is based on the studies by Pessoa (1991) and Orion (1993), taking into account the epistemological assumptions underlying each proposal. Based on these frameworks, the present study adopts the stages of Pre-Visit, Visit and Post-Visit as the structure for the development and implementation of the Educational Guide under analysis.

METHODOLOGY

This study adopts a qualitative, descriptive-interpretative research approach, implemented through a pedagogical intervention, involving the analysis of primary documents, as recommended by Creswell (2010). The documents were obtained from official websites, from materials such as information cards, and from records produced by the students in the *Teaching Guide for Visits to CAPPA*, which generated data consisting of students' written responses, response frequencies and drawings.

Data collection was carried out using the *Teaching Guide for Visits to CAPPA*, with the support of the class teacher of a Year 5 primary school class comprising 20 students aged around 11 from the municipal school system in the central region of Rio Grande do Sul. Fourteen students were present and participated on the day of the study visit.

The Guide comprises different types of questions: questions 1, 2, 3, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24 and 25 are multiple-choice; questions 11, 28, 29 and 30 are open-ended; and questions 4, 26 and 27 consist of responses in the form of images (drawings).

The data were analysed using content analysis, as described by Bardin (2016). The pedagogical approach that guided the activities carried out with the students followed the theoretical and methodological principles of Pessoa (1991) and Orion (1993) for field trips, organised into the Pre-Visit, Visit and Post-Visit stages. Table 2 summarises the teaching activities carried out with the students, highlighting the number of teaching hours, the estimated duration, the stages of the field trip, the resources used and how these activities were linked to the Study Guide.

Table 2

Educational Activities Carried Out Following the Visit.

Estimated time	Stages	Activities	Resources
Lesson 1 100 mins	Pre-Visit	A lecture on fossils, QCG, dinosaurs and their importance in life on Earth. Access to the CAPPA website.	Slides, computer, projector, blackboard and chalk. Quarta Colônia Palaeontological Research Support Centre https://www.ufsm.br/unidades-universitarias/ccne/cappa 

Lesson 2 100 mins	Pre-Visit	Clarification of questions. Preparation for the study visit.	Slides, videos, a projector, computers, a blackboard a chalk. The Quarta Colônia Geopark website. https://www.geoparquequartacolonia.com.br/home  Video about Cappa: https://youtu.be/o4EqUhDy9aA https://youtu.be/vR5FLQ4IXWw
Lesson 3 100 mins	Visit	Study visit to the QCG and CAPPA.	Educational Guide for Visits to CAPPA: mobile phon notebooks or computers. Link to the Guide: https://docs.google.com/forms/d/e/1FAIpQLSdsQWE VC_dutf579vQC7F3nU0fOY3JDzWihoqiGzmc060A wform?usp=header 
Lesson 4 150 mins	Post-Visit	Creating a Padlet. Revising the activity guide.	Computers, exercise books, pens, textbooks, website amongst other things.
Lesson 5 100 mins	Post-Visit	Sharing knowledge and preparing a summary of the topic covered.	Computer, notebook and pen, projector, amongst oth things.

Analysis of the responses provided by the 14 students who completed the questionnaire revealed three non-mutually exclusive analytical categories, which reflect different ways of acquiring knowledge about fossils and dinosaurs at the Quarta Colônia Geopark (QCG): i) responses influenced by knowledge derived from the media; ii) responses arising from activities experienced during the field trip; iii) responses relating to conceptually more complex topics.

The categories emerged from the analysis of the students' responses, in accordance with the categorisation procedures proposed by Bardin (2016).

The research was approved by the Research Ethics Committee (CEP) of Franciscan University under approval number 7,472,221. In accordance with the ethical procedures applicable to research involving minors, the students' participation was authorised by their legal guardians through the signing of the Informed Consent Form. Furthermore, the students themselves were informed, in language appropriate to their age group, about the objectives and procedures of the research and gave their consent to participate by signing the Informed Assent Form.

RESULTS AND DISCUSSION

The results of the 30 questions set out in the *Teaching Guide for Visits to CAPPA,* carried out with the support of the class teacher, indicate that the 14 students generally demonstrated a good understanding of the activities. Questions 1, 2, 3, 6, 7, 8, 9, 10, 12, 13, 16, 17, 23 and 24 did not appear to pose major difficulties and were answered correctly by the majority of students. Table 3 summarises the questions on which the majority of students achieved the highest levels of correct responses:

Table 3

A selection of questions from the guide and the results of this survey showing the questions on which the majority of the students surveyed answered correctly.

Questions	Correct answers
1. What is CAPPA?	13 students
2. In which town within the Quarta Colônia Geopark is CAPPA located?	8 students
3. What is the main work carried out by CAPPA's scientists?	12 students
6. What does palaeontology study?	12 students
7. What are fossils?	11 students
8. How were the fossils at the Quarta Colônia Geopark formed?	12 students
9. Fossils from the Quarta Colônia Geopark can mainly be found in:	12 students
10. An example of a fossil is:	11 students
12. Look at the pictures below and identify those that are considered to be fossils.	12 students
13. What are dinosaurs?	14 students
16. How do scientists know that dinosaurs existed?	13 students

17. What did dinosaurs eat?	11 students
23. Is it true that dinosaurs ate humans?	11 students
24. Look at the image below and tick the correct option regarding the reproduction of dinosaurs.	10 students

The questions relating to the formation of fossils and evidence of the existence of dinosaurs were answered correctly by the majority of students, as the visit to CAPPA provided an opportunity to observe the fossils and engage directly with the exhibits, thereby helping them to understand how science proves the existence of dinosaurs and the process of fossilisation.

For more detailed analysis, 10 questions (5, 8, 10, 14, 15, 16, 18, 21, 25 and 30) were selected for further analysis. Among these, questions 10, 15 and 30 were identified as more challenging, with a higher number of incorrect answers. Questions 10, 21 and 25, in turn, showed a wider range of answers, indicating different interpretations on the part of the students. Table 4 presents, for each category of analysis, the selection of 10 questions from the Guide and the data resulting from this investigation.

Table 4

Analysis Category, the Selection of the 10 Questions from the Guide, and the Data Resulting from This Investigation

i) Responses arising from the acquisition of knowledge under the influence of the media	
Questions from the Teaching Guide	**Students' responses**
14. During which period of the Mesozoic Era did the dinosaurs of the Quarta Colônia Geopark live?	Jurassic Period – 9 students Cretaceous Period – 3 students Triassic Period – 1 student Carboniferous Period – 1 student
15. Which image depicts the cause of the extinction of the dinosaurs at the Quarta Colônia Geopark?	A meteor strike – 13 students Lightning – 1 student Climate change – No response Human activity – No response
30. Do you know of any dinosaurs that lived in the Quarta Colônia Geopark area? If so, which ones?	No – 4 students Raptor – 1 student Burlvestes Schultz – 1 student Velociraptor – 1 student Tyrannosaurus – 1 student Dinosaur fossils – 6 students

(ii) Responses arising from the acquisition of knowledge gained from the activities carried out during the study visit	
Questions from the Teaching Guide	**Students' responses**
5. Look at the images below and mark with an 'x' the one or ones that represent the work carried out by CAPPA.	Fossil preparation – 8 students Fossil collection – 5 students Finding the T. rex fossil – 1 student Scanning a fossil – No students
10. An example of a fossil is:	A fossilised dinosaur bone – 11 students A stuffed animal – 2 students A plastic skeleton – 1 student An animal in a cage – No students
8. How were the fossils at the Quarta Colônia Geopark formed?	When the body of a living organism is covered by sediment, it undergoes a process of mineralisation – 12 students When a living organism freezes in a cold environment – 1 student When a living organism is buried and disappears quickly – 1 student When a living organism evaporates and leaves marks on the ground – No students
16. How do scientists know that dinosaurs existed?	Through fossils found during excavations – 13 students Through ancient legends – 1 student Through cave paintings – No students Because there are still living dinosaurs in Antarctica – No students
iii) Answers relating to conceptually more complex topics	
Questions from the Teaching Guide	**Students' responses**
18. What are coprolites?	Fossilised dinosaur bones – 6 students Fossilised prehistoric animal droppings – 6 students Preserved dinosaur footprints – 2 students Fossilised dinosaur eggs – No students
21. Apart from dinosaurs, what other animal fossils have been found in the Quarta Colônia Geopark?	Primitive reptiles and amphibians – 6 students Ice Age mammals – 4 students Modern birds – 3 students Giant insects – 1 student

25. Do you know what a dinosaur's tail is for?	To distinguish between males and females – 8 students To assist with movement, feeding or balance – 6 students

Based on the data presented in Table 4, each category of analysis is set out below, followed by a discussion of each.

i) The Influence of the Media on the Acquisition of Knowledge

In question 14 (In which period of the Mesozoic Era did the QCG dinosaurs live?), it was observed that the students displayed significant conceptual misunderstandings, as the majority answered 'Jurassic' (64.3 per cent), whilst the correct answer is the Upper Triassic. It was noted that an understanding of geological time is a topic which, in the early years of schooling, is not yet covered and is not easily grasped. Furthermore, there is a tendency to associate the term 'Jurassic' with works popularised by the media, particularly films, such as "*Jurassic Park"* (1993), directed by Steven Spielberg. This highlights the gap between scientific language and everyday language, which is often shaped by cultural representations. It also demonstrates that students' prior knowledge of a particular topic related to fossils does not always align with scientific knowledge.

Among the dinosaurs most widely publicised by the media and featured in children's imaginations, the *Triceratops* and *Stegosaurus homheni* stand out (Li *et al.,* 2024). Duarte *et al*. (2016) also emphasise that, although the topics of 'fossils' and 'geological time' hold great fascination and are of educational relevance, they are still rarely covered or explored in depth in primary and secondary education. The authors highlight the importance of devoting greater attention to the study of fossils in school settings, given that, very often, the only information students have on the subject comes from films, games and social media, which tend to present distorted or confusing content. Consequently, rather than understanding dinosaurs as creatures that belonged to a geological period, students may associate them with fictionalised representations, particularly those linked to the Jurassic, thereby distorting the scientific and geological context of the Triassic fossils found in the Quarta Colônia Geopark (Vestena & Vasconcelos, 2025).

In question 15 (Which image represents the cause of the extinction of the QCG dinosaurs?), the majority of students (92.9%) identified a meteorite impact as the cause of these animals' extinction. This result may also be linked to the influence of media portrayals on students' perceptions, as videos and

films depict the Cretaceous period and the impact of a meteorite as the decisive factor in the extinction of the dinosaurs of that period – an event that has been widely publicised and popularised. Media representations, however, tend to portray dinosaurs in a fantastical manner, emphasising aspects such as violence, gigantism and sensationalism. Such approaches may constitute epistemological obstacles to understanding their actual biological diversity, behaviour and historical context of existence (Bizzo & Carvalho, 2020).

The dinosaurs of the QCG lived around 160 million years before that event. The fossils found within the Quarta Colônia Geopark date from the late Triassic, a period during which another mass extinction occurred, known as the Triassic–Jurassic extinction (approximately 201 million years ago). This finding reinforces the idea that students tend to associate the event most widely publicised by the media – the meteorite impact at the end of the Cretaceous – with all dinosaur extinctions (Godoy *et al*., 2012).

In question 30 (Do you know of any dinosaurs that lived in the region where the QCG is located today? If so, which ones?), the answers also referred to those depicted in films, such as 'Tyrannosaurus', 'Velociraptor' and 'T. rex'. Only one student gave an answer which, despite being misspelt (*Buriolestes schultzi*), refers to Buriolestes schultzi, a dinosaur actually found in the QCG. Thus, the inclusion of studies relating to palaeontology in the classroom is of the utmost importance for students to understand the natural processes both geological and biological that have been operating on Earth for hundreds of millions of years (Izaguirry *et al*., 2014).

ii) The Influence of Knowledge Gained **from Activities Undertaken During the Visit**

The responses relating to the activities carried out during the visit to the Centre for Palaeontological Research Support (CAPPA/UFSM) indicated a more consistent grasp of scientific concepts. In question 4 (Record the scientific element that most aroused your curiosity during the visit to CAPPA/UFSM), the students were asked to draw a picture of what most caught their attention. It was observed that the drawings featured anatomical details, particularly of the skull and dental arch of the animal on display. The dinosaur found at the QCG, named *Gnathovorax cabreirai*, was among the oldest and largest predators known from its time; it lived during the Late Triassic, approximately 230 million years ago, was around 3 metres long, was carnivorous, and was discovered at the Piveta site in Restinga Sêca, RS (Garcia *et al*., 2021).

In question 5 (Look at the images below and mark with an X those that represent the work carried out by CAPPA), students were asked to identify the activities carried out by the centre, and were allowed to select more than one option. It was noted that only one student was unable to correctly identify the work carried out by CAPPA, with 92.9% of students selecting at least one correct activity.

In question 10 (What is an example of a fossil?), the majority (78.6%) answered correctly. In question 8 (How were the fossils at the Quarta Colônia Geopark formed?), it was noted that 85.7% of the students correctly understood the process of fossil formation, with only two failing to answer correctly. As for question 16 (How do scientists know that dinosaurs existed?), it was found that the majority of students demonstrated a satisfactory understanding (92.9%).

The scientific understanding of processes such as the mass extinction events affecting dinosaurs provides important insights into the analysis of recurring, large-scale environmental phenomena, enabling parallels to be drawn with contemporary challenges such as habitat loss, climate change and impacts on geodiversity, biodiversity and socio-environmental systems. Thus, on-site observations and direct contact with authentic fossils fostered the students' interest, curiosity and understanding of the fossilisation process and the region's geological context. This category of responses highlights the importance of teaching based on field trips and study visits, as advocated by authors who value a contextualised, inquiry-based and interdisciplinary approach to science education (Yemini *et al.,* 2023).

iii) Topics of Greater Conceptual Complexity

Other questions also revealed significant conceptual difficulties. In question 14 ('In which period of the Mesozoic Era did the QCG dinosaurs live?'), the majority of students (64.3%) incorrectly answered 'Jurassic'. In question 15 ('Which image represents the cause of the extinction of the QCG dinosaurs?'), 92.9% of participants indicated a meteorite impact. In question 18 ('What are coprolites?'), only 42.9% answered correctly that they are fossilised faeces; the rest confused coprolites with fossilised bones (42.9%) or fossilised footprints (14.3%). In question 21 (Apart from dinosaurs, what other animal fossils have been found in the QCG?), only 43 per cent of students answered correctly, whilst 57 per cent gave incorrect answers, mistakenly identifying organisms or groups inconsistent with the fossil record of the QCG (Gui *et al.,* 2023). As for question 25 (Do you know what a dinosaur's tail is for?), the majority (57%) stated that they did not know, even though its main function was to help the animal maintain its balance.

The conceptual difficulties mentioned, particularly those relating to the geological timescale, the processes of fossilisation and the distinction between local and global extinctions, underscore the fact that the study of fossils requires complex cognitive skills, such as observation, hypothesis formulation, systematisation and abstraction. Understanding the vastness of geological time is essential for interpreting the impact of slow and imperceptible processes that nevertheless result in profound changes, as is the case in geomorphology (Bonito *et al.,* 2011). These challenges become even greater when compounded by the influence of media representations, which often spread misconceptions, perpetuated by a lack of access to adequate scientific knowledge (Novais *et al*., 2015).

In this regard, it is worth highlighting the fundamental role of schools in providing knowledge and concepts that enable students to 'challenge' pre-existing information – which is sometimes incorrect and culturally reinforced – in order to construct knowledge aligned with scientific understanding. Boelter and Goldschmidt (2023) emphasise that palaeontological content in basic education faces various pedagogical challenges, starting with the way the subject is presented in official documents, such as the National Common Core Curriculum (Brazil, 2018). Novais *et al*. (2015) observe that science teaching, particularly with regard to geology and palaeontology, often fails to offer students effective ways of engaging with scientific knowledge, so that they can understand, question and apply it in everyday situations.

The breadth of knowledge involved in the study of fossils calls for teaching approaches that combine theory and practice, bringing students closer to the real-world contexts of scientific research. To this end, study visits to museums and research centres, such as CAPPA, prove particularly relevant. Science education should foster critical understanding and interest in scientific knowledge, highlighting the value of contexts such as the QCG, which enable the integration of natural heritage, Earth's history and local culture. For this reason, the inclusion in the school curriculum of topics involving dinosaurs, from the early years onwards, fosters a sense of belonging, care for the environment and appreciation of the QCG's fossils as a legacy for future generations (Vestena & Vasconcelos, 2025).

In this regard, visits to museums and research centres provide valuable opportunities to develop scientific reasoning, problem-solving skills and decision-making in the face of global challenges – all of which are central to scientific literacy (Cachapuz *et al*., 2004).

Knowledge relating to dinosaur fossils, when explored in a school context through activities such as field trips and study visits, constitutes an important form of teaching and scientific outreach (Orion, 1993). In this context, palaeontology emerges as a field capable of sparking the interest of both students and the general public, promoting the understanding and interpretation of topics involving not only fossils, but also the environments in which these organisms lived and the geological periods of the past (Oliva, 2018).

It is therefore essential that teaching resources designed to support teachers are developed in such a way as to provide meaningful experiences that encourage inquiry, critical thinking and the autonomous construction of knowledge. From this perspective, resources such as teaching guides, guided visits and practical activities play a central role in linking theoretical content with real-life experiences, facilitating the understanding of complex concepts and promoting interdisciplinarity in the educational process. In this regard, visiting museums and science centres enables content to be experienced first-hand (Yemini *et a*l., 2023). Taking into account the stages proposed by Orion (1993) and Pessoa (1991), subdivided into the Preparation Unit (Pre-Visit), the Visit and the Synthesis Unit (Post-Visit), it was observed that this structure proved to be highly effective for the teacher's didactic organisation, for the systematisation of learning and for recording students' knowledge. Furthermore, the material produced serves as a means of documenting and evaluating the teaching and learning process (Orion, 1993).

From a scientific perspective, the *Educational Guide for Visits to CAPPA* has enabled a deeper understanding of the dinosaurs at the QCG, providing students with the opportunity to observe, organise and record knowledge about the local palaeontological heritage. For teachers, the guide serves as a pedagogical tool capable of assisting in the planning and delivery of field trips, fostering dialogue between scientific knowledge and educational practice (Heyde & Doyle, 2022; Yemini *et al*., 2023). Overall, the results obtained demonstrate that the Teaching Guide made a tangible contribution to the teaching and learning process, acting as a resource to structure teaching practice and as a bridge between academic/scientific knowledge and school learning. Its use facilitated not only the organisation of and critical reflection on the educational visit, but also the assessment of the knowledge acquired by the students.

CONCLUSIONS

The aim of this study was to analyse how the use of an educational guide, designed to facilitate study visits to the Centre for Palaeontological

Research Support (CAPPA/UFSM), can promote the acquisition of knowledge about the fossils found within the Quarta Colônia Geopark (QCG). The results showed that the *Educational Guide for Field Trips to CAPPA* proved effective in the pedagogical organisation of the activity, stimulating interest, scientific curiosity and the systematisation of the students' experiences.

The findings indicate that, by engaging with content related to dinosaur fossils, the students were able to understand more complex scientific concepts, demonstrating engagement and active participation with the activities facilitated by the guide and the visit. The educational experience reinforced the importance of structured planning that takes into account the pre-visit, visit and post-visit stages, as discussed by Orion (1993). Such an approach highlights the potential of research centres and geoparks as educational spaces that expand opportunities for teaching and learning.

It was also found that, although the students held preconceptions stemming from media representations strongly shaped by films and science-fiction productions, the use of the teaching guide encouraged them to question and deconstruct these misconceptions. In this way, it contributed to strengthening learning that was scientifically grounded and contextualised within the Quarta Colônia Geopark. The investigative and participatory activities, particularly the visit to CAPPA, proved highly effective in sparking interest, stimulating critical thinking and encouraging students' engagement with study and research, thereby consolidating their knowledge of palaeontology and local geological history.

The importance of producing and making available contextualised teaching materials which integrate theory and practice, promote the palaeontological heritage and strengthen the links between schools, the territory and the local community is therefore reaffirmed. It is concluded that the teaching guide has contributed not only to the teaching of science but also to the appreciation of the natural and cultural heritage of Quarta Colônia, thereby fostering the development of students' scientific and cultural identity. Future research should the application of the guide be extended to different educational levels and contexts, in order to assess its adaptability and its potential to promote dialogue between education, science and heritage, thereby strengthening the principles of Heritage Education and Science Education within the context of geoparks.

ACKNOWLEDGEMENTS

Franciscan University, Brazil; Centre for Palaeontological Research Support; Quarta Colônia Geopark; and the Coordination for the Improvement of Higher Education Personnel – Brazil (CAPES). Strategic Funding (ref. UID/04423/2025, UID/PRR/04423/2025 and LA/P/0101/2020), through national funds from the Foundation for Science and Technology (FCT), Portugal.

AUTHORS' CONTRIBUTION STATEMENT

RFV and DF conceived the idea presented and developed the proposal for the material. ARRA implemented the proposal and assisted in drafting the methodology, together with RVF, DF and MSH, who carried out the analysis and discussion of the data, under the supervision and review of CMV. All authors actively participated in discussing the results and reviewed and approved the final version of the paper.

STATEMENT ON DATA AVAILABILITY

The data supporting the findings of this study will be made available by the corresponding author, RFV, upon request.

REFERENCES

Anelli, L.E.; Leme, J.M.; Oliveira, P.E.; Fairchild, T, R. (2020). Palaeontology: A Guide to Practical Classes – An Introduction to the Study of Fossils. *Institute of Geosciences*, (8), 104p.

Barberena M. C. (1978). A huge tecodont skull from the Triassic of Brazil. *Pesquisas* 9: 62-75.

Bardin, L. (2016). *Content Analysis. Edições 70*.

Beck, J., & Lopes, J. (2021). *Guinness recognises that the world's oldest dinosaurs were found in Rio Grande do Sul. G1, RBS, Rio Grande do Sul.*https://g1.globo.com/rs/rio-grande dosul/noticia/2021/08/06/guinness-reconhece-que-dinossauros-mais-antigos-domundo-foram-encontrados-no-rs.ghtml

Bizzo, N., & Carvalho, G. S. (2020). *Teaching evolution and the history of life: contemporary challenges. Cortez.*

Boelter, R. A., & Goldschmidt, A. I. (2023). Teaching Palaeontology in the Early Years: exploring children's imagination through images. *Insignare Scientia Journal – RIS,* 6 (6), 679–709. https://doi.org/10.36661/2595-4520.2023v6n6.13950

Bonito, J., Rebelo D., Morgado M., Monteiro G., Medina, J., Marques, L., & Martins L. A. (2011). The complexity of geological time and teaching it to Portuguese pupils. Terra e Didática, (7), 60-71. https://doi.org/10.20396/td.v7i2.8637431.

Brazil. Ministry of Education. (2018). *National Common Core Curriculum. Brasília*, DF: MEC. https://basenacionalcomum.mec.gov.br/.

Brusatte, S. (2019). *The Rise and Fall of the Dinosaurs: a new history of a lost world*. (3ª ed.). Record.

Cabreira, S. F., Schultz, C. L., Bittencourt, J. S., Soares, M. B., Fortier, D. C., Silva, L. R., & Langer, M. C. (2011). New stem-sauropodomorph (Dinosauria, Saurischia) from the Triassic of Brazil. *Die Naturwissenschaften*, *98*(12), 1035–1040. https://doi.org/10.1007/s00114-011-0858-0

Cabreira, S. F., Kellner, A. W. A., Silva, S. D., Silva, L. R. da., Bronzati, M., Marsola, J. C. de A., Müller, R. T., Bittencourt, J. de. S., Batista, B. J. A., Raugust, T., Carrilho, R., Brodt, A., & Langer, M. C. (2016). A unique Late Triassic dinosauromorph assemblage reveals dinosaur ancestral anatomy and diet. *Current Biology*, *26* (22), 3090-3095. https://doi.org/10.1016/j.cub.2016.09.040

Cachapuz, A., Praia, J., & Jorge, M. (2004). From science education to guidelines for the teaching of science: an epistemological rethinking. Science & Education (Bauru), *10*(3), 363–381. https://doi.org/10.1590/S1516-73132004000300005

CAPPA. *Palaeontological Research Support Centre.*(2025). https://www.ufsm.br/unidades-universitarias/ccne/cappa

Creswell, J. W. (2010). *Research project: qualitative, quantitative and mixed-methods approaches*. (3ª ed.). Artmed.

Duarte, S.G., Arai, M., Passos, N.Z.G., & Wanderley, M.D. (2016). Palaeontology in Primary Education in Rio de Janeiro's State Schools: A Critical Assessment. Yearbook of the Institute of Geosciences, *39*(2), 124–132. https://doi.org/10.11137/2016_2_124_132

Franco, A. S., Müller, R. T., Martinelli, A. G., Hoffmann, C. A., & Kerber, L. (2021). The nasal cavity of two traversodontid cynodonts (Eucynodontia, Gomphodontia) from the Upper Triassic of Brazil. *Journal of Paleontology*, *95*(4), 845–860. https://doi.org/10.1017/jpa.2021.6

Garcia, M. S., Müller, R. T., Pretto, F. A., Da-Rosa, Á. A. & Dias-Da-Silva, S. (2021). Taxonomic and phylogenetic reassessment of a large-bodied dinosaur from the earliest dinosaur-bearing beds (Carnian, Upper Triassic) from southern Brazil. *Journal of Systematic Palaeontology*, *19*(1), 1-37. https://doi:10.1080/14772019.2021.1873433

Godoy, M. M., Binotto, R. B., Silva, R. C., & Zerfass, H. (2012). *Quarta Colônia Geopark (RS) – Proposal. Institutional Geosciences Repository.* https://rigeo.sgb.gov.br/handle/doc/17170.

Gomes, P., Santos, C., & Oliveira, J. (2020). *Development of educational activities for the interpretation of cultural and natural heritage: a guide to visitor activities. Editora Educacional.*

Gui, S. M., Liu, Y. C., & Tian, L. (2023). Evolution of insect diversity in the Permian and Triassic. *Palaeoentomology*, *6* (5), 472-481. https://doi:10.11646/palaeoentomology.6.5.6

Heyde, V. V. D., & Doyle, J. (2022). Accelerating transformation through placed-based learning. Field Actions Science Reports. *The Journal of Field Actions*, *24* (1), 98-101.

Izaguirry, B. B. D., Ziemann, D. R., Müller, R. T., Dockhorn, J., Pivotto, O. L., Costa, F. M., Alves, B. S., Ilha, A. L. R., Stefenon, V. M., & Dias-da-Silva, S. (2014). Palaeontology in schools: A fun and educational

approach in schools in the municipality of São Gabriel, RS. Cadernos da Pedagogia, *7*(13), 2-16.

Kerber, B. B., Elmola, A. Abd., Zhuravlev, Z., Gaucher, C., Simões, M.G., Prado, G.M.E.M., Vintaned, J.A. Gámez., Fontaine, C., Lino, L.M., Sanchez, D. Ferreira., Galante, D., Paim, P.S.G., Callefo, F., Kerber, G., Meunier, A., & El Albani, A. (2022). Clay templates in Ediacaran vendotaeniaceans: Implications for the taphonomy of carbonaceous fossils. *Geological Society of America Bulletin*. http://dx.doi.org/10.1130/B36033.1

Li, N., Li, D., Peng, G., & You, H. (2024). The first stegosaurian dinosaur from Gansu Province, China. *Cretaceous Research*, *158*, 105852. https://doi:10.1016/j.cretres.2024.105852

Müller, R. T., Langer, M. C., & Dias-da-Silva, S. (2018). An exceptionally preserved association of complete dinosaur skeletons reveals the oldest long-necked sauropodomorphs. *Biology letters*, *14*(11), https://doi.org/10.1098/rsbl.2018.0633

Müller, R. T. (2023). The role of Brazil in the golden age of dinosaur origins discoveries. *Anais da Academia Brasileira de Ciências*, *95* (1). https://doi.org/10.1590/0001-3765202320220338

Novais, T., Martello. A. R., Oleques, L. C., Leal, L. A., & Da-Rosa, Á. A. S. (2015). An experiment in integrating palaeontology into primary school education in different regions of Brazil. Terra e Didatica, *11*(1), 33-41.

Oliva, E. (2018). Teaching palaeontology in non-formal settings [Master's thesis, University of Évora]. *University of Évora Repository.* http://hdl.handle.net/10174/23275.

Orion, N. A. (1993) Modell zur Entwicklung und Durchführung von Exkursionen als fester Bestandteil des naturwissenschaftlichen Lehrplans. *School Science and Mathematics*, *93* (6), 325-331. https://doi.org/10.1111/j.1949-8594.1993.tb12254.x

Pacheco C, Müller RT, Langer M, Pretto FA, Kerber L., & Dias, S. S. (2019). Gnathovorax cabreirai: ein neuer früher Dinosaurier sowie der Ursprung und die frühe Radiation der Raubdinosaurier. *PeerJ* 7: e7963 https://doi.org/10.7717/peerj.7963.

Pessoa, J. E. (1991)**.** *Studienbesuch: eine Strategie für das Lehren und Lernen.*Papirus.

Pretto, F. A., Langer, M. C., & Schultz, C. L. (2018). A new dinosaur (Saurischia: Sauropodomorpha) from the Late Triassic of Brazil provides insights on the evolution of sauropodomorph body plan. *Zoological Journal of the Linnean Society*, 185 (2), p. 388–416. https://doi.org/10.1093/zoolinnean/zly028

Pretto F. A. (2021). Vor der Geschichte: Die vierte Kolonie in der Urzeit. In Padoin, M. M., Figueiró, A., Cruz, J. A. S. (Ed.), *Vermögensbildung in Geopark-Gebieten: Ein interdisziplinärer Ansatz in der „Quarta Colônia“.* (1 ed., 1 Vol., pp. 19-3). Facos-UFSM.

Rosa. A. A. S. da. (2018). Paläontologisches Erbe vs. städtisches Wachstum: Das Schicksal der Trias-Fossilien im Süden Brasiliens. *Acesso Livre*, (9), jan.-jun. 103-117. https://revistaacessolivre.wordpress.com/wpcontent/uploads/2018/06/acesso_livre_9.pdf

Vasconcelos, C., & Ribeiro, T. (2025). The interplay of geoheritage and outdoor experiences through education and communication. In E. Reynard & J. Brilha (Eds.), *Geoheritage: Assessment, Protection, and Management (2nd Edition*) (pp. 411-430). Elsevier. doi: https://doi.org/10.1016/B978-0-443-28997-2.00016-9

iana, M. S. S.; Carvalho, I. de S. (2019) *Paläontologisches Erbe.* Interciência.

Yemini, M., Engel, L., & Ben, S., A. (2023). Place-based education–a systematic review of literature. *Educational Review*, *77* (2), 640-660. https://doi.org%2f10.1080%2f00131911.2023.2177260 .

Vestena, R. F., Vasconcelos, C. M. (2025). Students' and Teachers' Conceptions of Dinosaurs from the Quarta Colônia Geopark (RS, Brazil). *Acta Scientia*.27(3) 1-27, Jul. Set..

Zucon, M. E. (2011). *Paleontology: Unveiling the History of Life on Earth.* Editora Mediação.