



A thematic review on interpretation perspective of UNESCO Global Geoparks over the past 5 years (2019-2024): Analysis of trends for future studies

Zoë Jiabo Zhang^{ab} | Mohd Hafizal Bin Ismail^a  | Noor Jalilah Binti Jumaat^a | Xiaoyang Pan^c

^aDepartment of Nature Parks and Recreation, Faculty of Forestry and Environment, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.

^bWudalianchi UNESCO Global Geopark, Heilongjiang Province, China.

^cDepartment of Sport Studies, Faculty of Education Studies, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.

Abstract The interpretation of the geological, geomorphological, and archeological significance of these geosites will assist visitors in comprehending and appreciating their importance to our heritage and the significance of their protection for future generations. The apparent lack of attention to interpretation in the geopark field has raised concerns among researchers and park authorities about how to promote the most effective interpretation principles when interpretive design and practice are popularized, despite the promising development of interpretive research. This study evaluates articles published between 2019 and 2024 to explore how interpretation is addressed in the context of the UNESCO Global Geoparks. Using a thematic review methodology, this research incorporates keywords from the SCOPUS and WoS databases. The thematic review analysis revealed four key themes: effective interpretation, geoconservation and SDGs, geoeducation and awareness, and the promotion of geotourism. The findings provide valuable insights for park policymakers, visitors, practitioners, and researchers interested in the interpretation field related to UNESCO Global Geoparks.

Keywords: interpretation, geoconservation, SDGs, geoeducation, geotourism

1. Introduction

Preserving heritage is a shared duty that all humanity must uphold (Liuzza, 2020; Cheng & Chen, 2022). Tourism may be an effective method for promoting and preserving this heritage while also serving as a beneficial force for conservation and education; however, it is crucial to consider both the advancement of the region for present generations and the conservation of its abundant heritage for future generations (Beraaouz et al., 2019; de Freitas & Koskowski, 2021). Geotourism, which was previously regarded as a niche form of tourism, has recently gained significant popularity as a themed form of tourism (Hose, 2007; Reynard, 2017; Dowling & Newsome, 2018). It has been one of the most rapidly expanding sectors of the tourism industry in the past decade (Ólafsdóttir, 2019). A prominent feature of geotourism has been geoparks (Singh et al., 2021; Xu & Wu, 2022), and the term "geopark" has a wide range of definitions and has been employed to describe spaces ranging from small outcrops to large geographical areas whose management can contribute to sustainable development (Beraaouz et al., 2019). In particular, the UNESCO Global Geoparks should establish themselves as model regions for sustainable development and enable both inhabitants and visitors to understand and appreciate what is special about their region (Stolz & Megerle, 2022). Since November 2015, UNESCO has formally designated the UNESCO Global Geopark (UNESCO Global Geoparks, 2024), along with the already well-known designations of the World Heritage Site and Biosphere Reserve. UNESCO Global Geoparks represent integrated territorial units in which sites and landscapes of international geological importance are administered through a comprehensive framework encompassing conservation, education, and sustainable development.

The primary objective of a geopark, in accordance with the overarching aim of UNESCO Global Geoparks, is to ensure the preservation and conservation of the geological heritage sites within its boundaries, with the ultimate goal of attaining a sustainable future (Wang & Zouros, 2021; Mc Keever & Zouros, 2005). The commitment is strengthened by the "World After Roadmap," the action plan of UGGps post-COVID-19 (Martini et al., 2022). This plan proposes actions that are in line with local sustainable development goals and the achievement of Sustainable Development Goals (SDGs) (Global Geoparks Network International Association, 2024). It recognizes the substantial contribution of UGGps to the attainment of SDGs (da Silva, 2020).

The interpretation of geosites is widely acknowledged as a very important tool for the management of geological heritage as a part of a policy for the sustainable development of tourism (Neches, 2016; Morante-Carballo et al., 2023). The explanation of the geological, geomorphological, and archeological significance of these geosites will help visitors understand and appreciate their significance to our heritage and the importance of their protection for future generations. Interpreting geological, natural, and cultural heritage is a highly effective strategy for promoting geological protection, geological education,



geological tourism, and popular science (Wang & Zouros, 2021). The basic principles of modern interpretation were first set out by Freeman Tilden, working in the USA's National Park Service (Tilden, 1957). In the years since Tilden's seminal work, accepted professional best practices in interpretation have been developed by authors such as Mike Gross, Sam Ham, and John Veverka (Gross et al., 2006; Ham, 2013; Veverka, 2015).

The interpretation methods used in global geoparks include various media, such as geological and archeological booklets, guidebooks or interpretive panels at geosites. The training of guides among the local population and the construction of museums in the area are very important. The Santa Elena Peninsula Geopark Project designed Geotourism Interpretation Centers (GICs) using sustainable and architectural criteria to improve geoeducation and geotourism (Rubira-Gómez et al., 2024). In the context of the ABC (abiotic, biotic, and cultural interconnections) concept, the Colca and Volcanoes Andagua UNESCO Global Geopark (Peru) and Muroto UNESCO Global Geopark (Japan) served as case studies. These examples demonstrate a potential interpretive approach that can be employed to popularize Earth heritage through geotourism (Pásková et al., 2021). The UNESCO Global Geopark (UGGp) is a complex region that demands many strategies to advance geological preservation, increase public consciousness, implement comprehensive heritage management, and foster sustainable development. UGGps require a wider range of digital technologies that are practical and applicable to address these issues (Fassoulas et al., 2022). For example, the Psiloritis UGGp in southern Greece developed an interactive digital map under the implementation of the "Enhancement Plan" of the geopark via the RURITAGE to aid the interpretation of natural and cultural heritage. San Isidro Pass, located northwest of the Iberian Peninsula, uses a relatively new approach, augmented reality (AR), as an educational tool for the interpretation of geological and geographic features (Rodríguez et al., 2022). With a geological heritage of international importance, the UNESCO Global Geoparks can become excellent field laboratories for educational and research activities in the earth and nature sciences. The well-designed geotrails link local geology, geoheritage and geoeducation. Geotrails are valuable resources for the field of geography and natural history, as they amusingly explain the phenomena associated with inanimate nature and geoheritage (Drápela, 2023). Swabian Alb Geopark (Germany) and Penha Garcia Ichnological Park designed good geotrails and fossil trails that enable both inhabitants and visitors to understand and appreciate what is special about their region (Stolz & Megerle, 2022; Neto De Carvalho et al., 2021).

Researchers and operators of geoparks note the importance of interpretation as a valuable tool in conserving geological heritage. Nevertheless, it will be intriguing to observe the patterns that arise from the prior literature, utilizing interpretation research in conjunction with geoparks. This study aims to conduct a thematic review of the discussions on interpretation and geoparks that were published from 2019–2024. The research questions guiding this review are as follows:

What are the current trends in interpretation studies related to the UNESCO Global Geoparks reported in the literature from 2019–2024?

2. Materials and Methods

The term thematic review uses ATLAS.ti as the tool as introduced by Dr. Zairul (Zairul & Zairul, 2020; Zairul et al., 2023). This method has also been protected by copyright under the registration number CRLY2023W02032 (Zairul, 2023). Figure 1 serves as the foundation for this study's methodology, guiding the adoption of TreZ through the thematic analysis procedure used for the literature review. Braun and Clarke (2006) describe thematic analysis as a methodological approach involving systematic identification of patterns and the subsequent construction of themes through comprehensive engagement with the data. To analyze the trends in interpretation studies related to UNESCO Global Geoparks in publications, the subsequent stage assesses the practice and creates categories. Our main objective is to examine and assess the results to suggest future interpretation research at Global Geoparks.

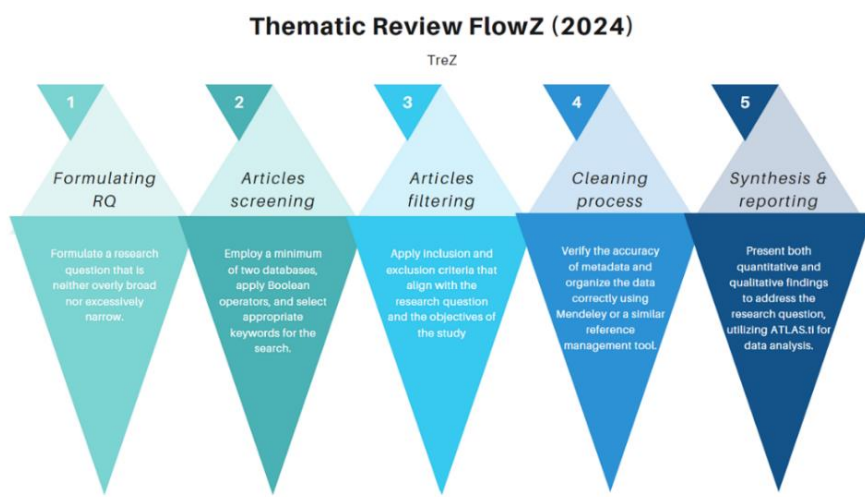


Figure 1 Thematic Review FlowZ (TreZ) *Source:* (Zairul, 2023).

The process commences with the formulation of the research question (Define RQ) (see previous section), which functions as a roadmap for the subsequent stages of the review, establishing the focus and scope. The articles were selected on the basis of a variety of inclusion criteria: 1) contained the keywords interpretation and UNESCO Global Geoparks; 2) recent 5 years (2019--2024); 3) written in English; and 4) document type focused on articles in the Web of Science and SCOPUS. The exclusion criteria were as follows: 1) any review articles or proceedings papers or conference papers or book chapters; 2) articles written in languages other than English; 3) no interpretation or UNESCO Global Geoparks; and 4) incomplete papers. Table 1 presents the search strings used for the literature retrieval conducted in SCOPUS and Web of Science.

Table 1 Search strings from Scopus and WoS.

SCOPUS	(TITLE-ABS-KEY ("interpretation" OR "interpretive" OR "interpreter" OR "interpreters") AND TITLE-ABS-KEY ("Geopark" OR "geopark" OR "UNESCO Global Geopark")) AND PUBYEAR > 2018 AND PUBYEAR < 2025	79 results
WoS	"interpretation" OR "interpretive" OR "interpreter" OR "interpreters" (All Fields) and "Geopark" OR "geopark" OR "UNESCO Global Geopark" (All Fields) and 2024 or 2023 or 2022 or 2021 or 2020 or 2019 (Publication Years)	70 results

The primary data sources were retrieved by searching two major academic databases, SCOPUS and Web of Science, which were chosen for their comprehensive coverage of peer-reviewed journals relevant to interpretation and UNESCO Global Geoparks. In SCOPUS, the search was defined with the keywords "interpretation" OR "interpretive" OR "interpreter" OR "interpreters" and "Geopark" OR "geopark" OR "UNESCO Global Geopark" in the title, abstract, and keywords (TITLE-ABS-KEY), targeting publications from 2019--2024, and restricted to academic articles in English that were (LIMIT-TO (DOCTYPE, "ar") and LIMIT-TO (LANGUAGE, "English"). This search strategy resulted in 79 articles, indicating a substantial body of recent literature. Interestingly, there was little difference between the number of literature searches in Web of Science. The Web of Science uses the same keywords across all fields without specific field restrictions and focuses on articles in English and publications from 2019--2024. This approach yielded 70 results. This research meticulously outlined and executed a selection process to identify the methodological steps undertaken, ensuring a robust selection of studies that enhance the validity and reliability of my review findings.

Of those articles, 108 documents were excluded because the studies did not discuss related topics or immature results. In addition, 17 papers were confirmed to be duplicates. Figure 2 clearly illustrates that a total of 22 articles were ultimately selected for evaluation. These articles were uploaded as primary files into ATLAS.ti 25, and each piece was then categorized by 1) author; 2) journal; 3) publisher; 4) issue number; 5) volume number; and 6) year of publication. The final 22 articles were imported into ATLAS.ti 25 for further analysis.

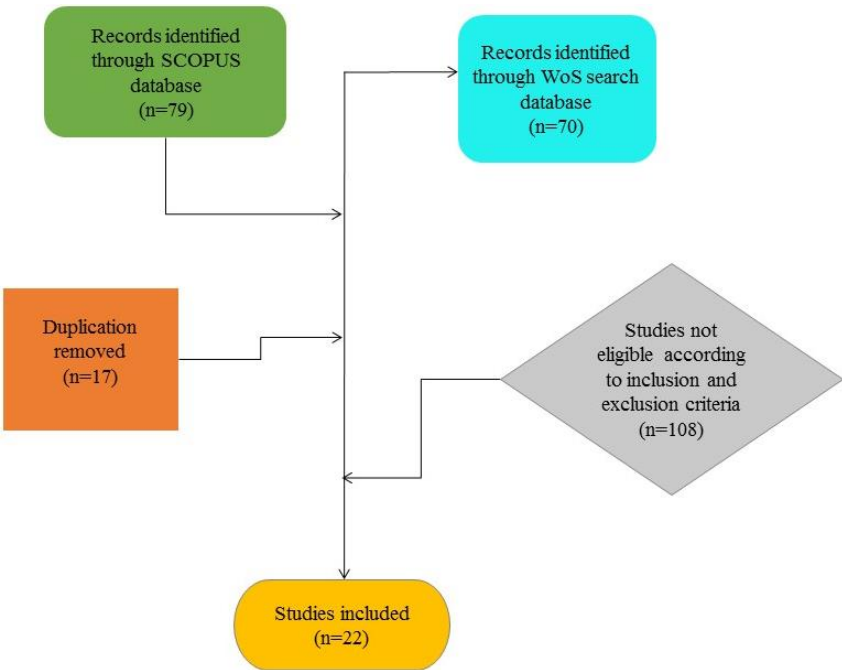


Figure 2 Inclusion and exclusion criteria in the thematic review.

In the qualitative part of the analysis, thematic analysis induction is used to move much of the collected data from specific content to wider generalizations and eventually to theory to ensure that themes are effectively linked to the data (Patton, 1990). This process involves coding, categorizing, and noticing patterns, which are themes that can be provided at different levels (Braun & Clarke, 2006). The findings of this study were obtained via both qualitative and quantitative



approaches. The quantitative part presents data from a numerical perspective, whereas the qualitative part identifies themes established from selected articles.

The literature included in the final analysis pertains to the interpretation and study area of the UNESCO Global Geoparks. Figure 3 depicts the geographical distribution of relevant research, while Figure 4 presents the number of articles published by country on the research topic. Figure 3 and Figure 4 indicate relatively consistent engagement among countries in interpreting and geoparks. The analysis of current trends in interpretation studies related to the UNESCO Global Geoparks from 2019--2024, which is based on the geographical distribution of publications, reveals a broad international interest with notable contributions from several countries.

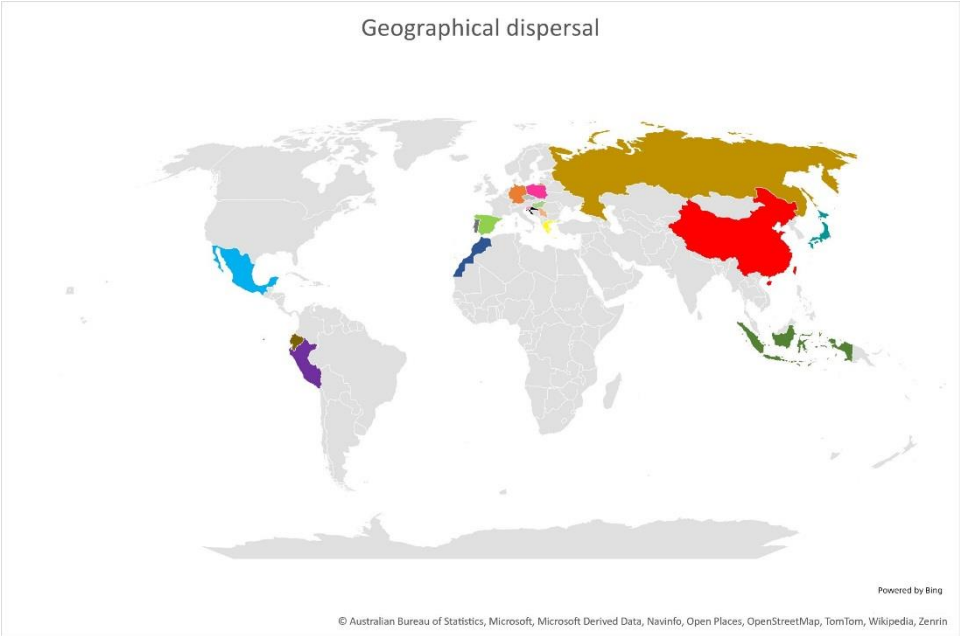


Figure 3 Paper distribution according to the country of publication.

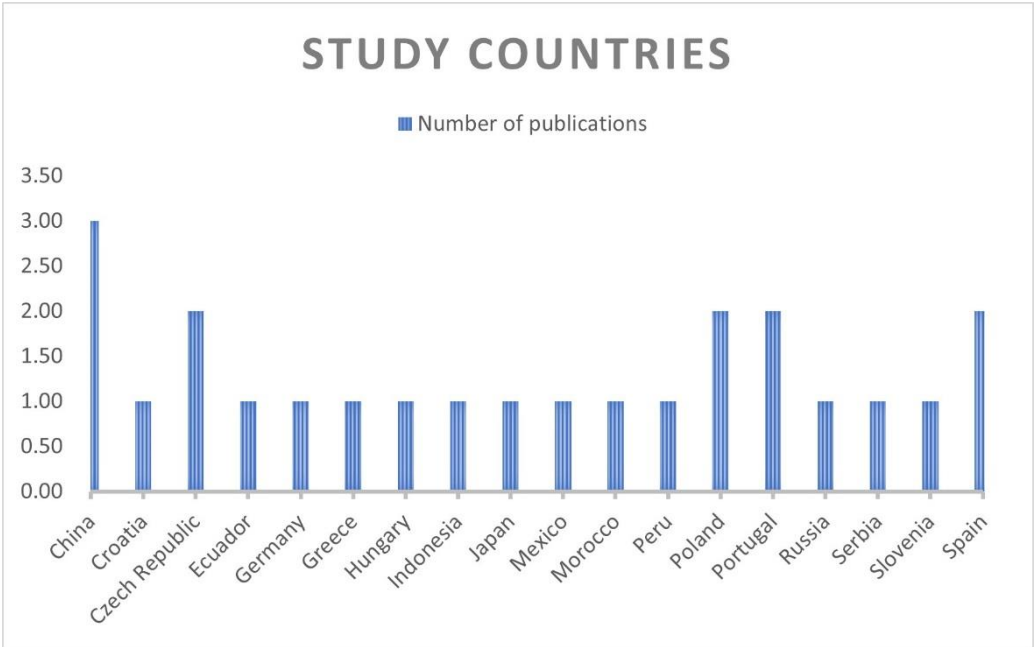


Figure 4 Number of articles based on country publication. *Source:* Scopus and WoS databases.

European countries such as Portugal, Spain, and Poland present significant research activities, reflecting efforts to integrate visitors and local communities to enhance educational outreach through traditional signs, panels and innovative technologies such as augmented reality. Latin American countries such as Ecuador and Peru contribute to the understanding of geodiversity and the promotion of geotourism. China has the highest number of publications, indicating a strong focus on geoconservation education and sustainable tourism practices in the region in recent years. From the article numbers, we know



that Europe still emerges as the region with the most extensive Geopark research, whereas Africa contributes the least in this regard.

3. Results and Discussion

In this thematic review (TrEZ), we provide a five-year summary of the patterns and trends in interpretation studies that are relevant to the publications and research of the UNESCO Global Geoparks. The results have been categorized into quantitative and qualitative sections. The quantitative section commences with a word cloud that was produced through the examination of the 22 primary documents. The authors are then analyzed in accordance with their themes. Insights into the various aspects of interpretation studies in geoparks are provided by the review and findings, which contribute to the literature. The primary findings of this thematic review are summarized, emphasizing the critical areas in which interpretation can contribute to the sustainable development of geoparks. The qualitative evaluation is further strengthened by quantitative analysis, which provides quantitative data and qualitative insights to address the research question.

After the review of the 22 articles, trends and patterns were identified in the subsequent qualitative analysis. Figure 5 below illustrates the culmination of the coding and code merging process conducted in ATLAS.ti 25, through which four significant themes emerged from the identified trends and patterns.

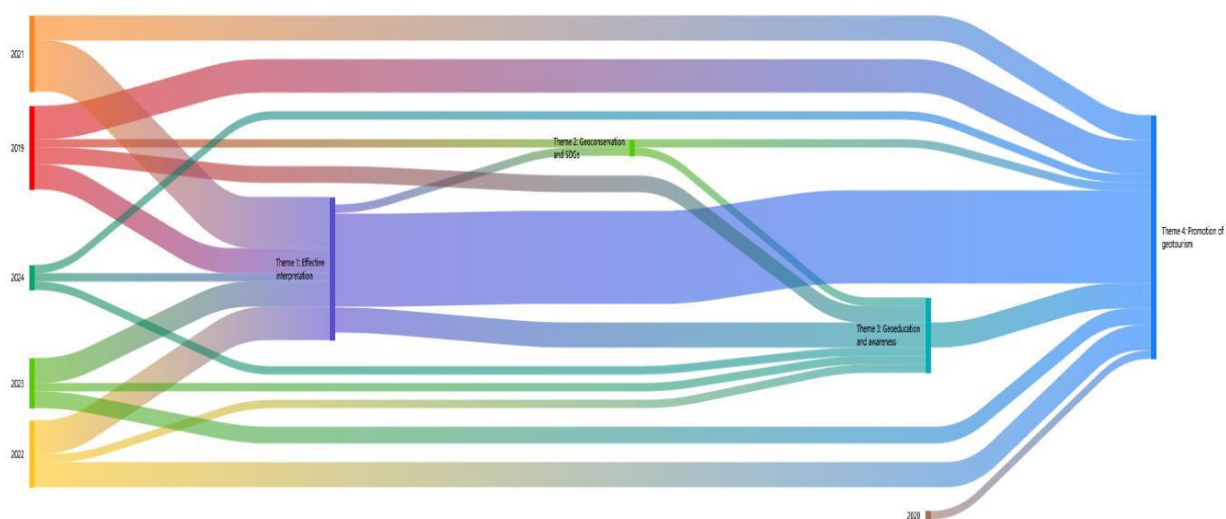


Figure 5 Themes discussed in the literature.

3.1. Quantitative reporting

The words "geopark" and "interpretation" are the most significant words in the word cloud, which suggests a high frequency in the documents in the preliminary analysis. In Figure 6, the word cloud from the 22 papers shows high-frequency words, such as "geopark" (817 times), "interpretation" (450 times), "geotourism" (554 times), "geoheritage" (558 times), and "educational" (253 times). The theme is precisely aligned with the frequency of word cloud displays.

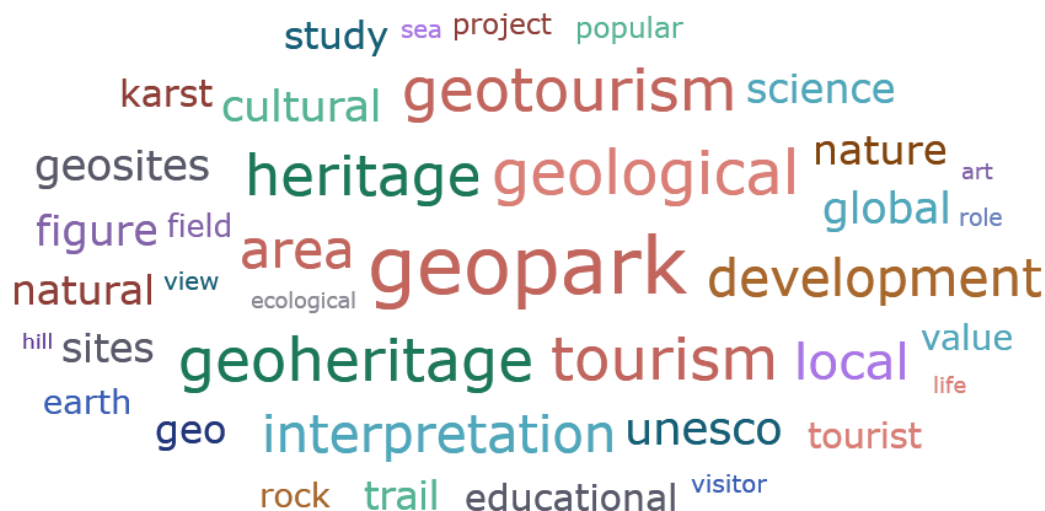


Figure 6 Word cloud generated from 22 articles.

Table 2 presents a thorough classification of research articles that focus on various aspects of interpretation in geoparks. The themes emphasize the diverse topics and approaches that researchers have addressed, such as effective interpretation, geoheritage conservation and SDGs, geoeducation and awareness, and the promotion of geotourism. Each theme makes a distinct contribution to the comprehension of the significance of interpretation in geoparks for sustainable development and, in addition, to the enhancement of global knowledge sharing and capacity building.

Table 2 Author vs. theme.

	Theme 1: Effective interpretation	Theme 2: Geoconservation and SDGs	Theme 3: Geoeducation and awareness	Theme 4: Promotion of geotourism
(Beraaouz et al., 2019)	0	0	0	1
(Fassoulas et al., 2022)	1	1	0	1
(Wang & Zouros, 2021)	0	2	2	0
(Rodríguez et al., 2022)	1	0	0	0
(Migoñ & Pijet-Migoñ, 2022)	1	0	1	0
(Vegas et al., 2019)	2	1	1	1
(Gajek et al., 2019)	0	0	1	1
(Mikhailenko & Ruban, 2019)	1	0	0	1
(Stolz & Megerle, 2022)	1	4	0	1
(Prieto et al., 2019)	1	0	0	0
(Antić et al., 2023)	1	0	0	1
(Long et al., 2022)	0	0	1	0
(Rubira-Gómez et al., 2024)	1	2	1	1
(Brzezińska-Wójcik & Skowronek, 2020)	0	1	0	1
(Pásková et al., 2021)	1	0	0	0
(Muzambiq et al., 2021)	1	1	0	1
(Neto De Carvalho et al., 2021)	1	0	0	1
(Breg Valjavec et al., 2022)	1	1	0	1
(Luan & Wang, 2023)	1	0	0	1
(Kordos et al., 2021)	1	0	0	1
(Figueiredo et al., 2021)	1	0	0	0
(Drápela, 2023)	1	0	1	0

3.2. Qualitative reporting

The qualitative analysis yielded four overarching themes, and this section elaborates on the specifics that were gathered to address the research question. The thematic analysis of a variety of papers was employed to discuss the four themes previously mentioned. This section provides a more detailed and specific description of the themes used to address the research question. The diagram in Figure 7 provides a comprehensive overview of the current trends in interpretation studies in geoparks from 2019--2024. Theme 1 is "Effective interpretation", which is the most prominent with 18 mentions and discusses the various interpretation methods applied in Global Geoparks, such as museum panels, design criteria for geological trails and fossil trails, visibility of geological remains and application of virtual technology. Theme 2 is "Geoconservation and SDGs", with 13 mentions, which explains that one of the main goals of the sustainable development of the geopark is to achieve the Sustainable Development Goals by 2030. Theme 3 is "Geoeducation and awareness", with 8 mentions, which emphasize that geological education is one of the main pillars of the operation of the geopark and that geological education further realizes the popularization of scientific knowledge to the public through interpretation. Theme 4, "Promotion of geotourism", has 14 mentions and explains that tourists are increasingly drawn to global geoparks because of their invaluable geological heritage resources. The demand for professional interpretation of geoparks is also increasing to further increase the appeal of geological tourism.

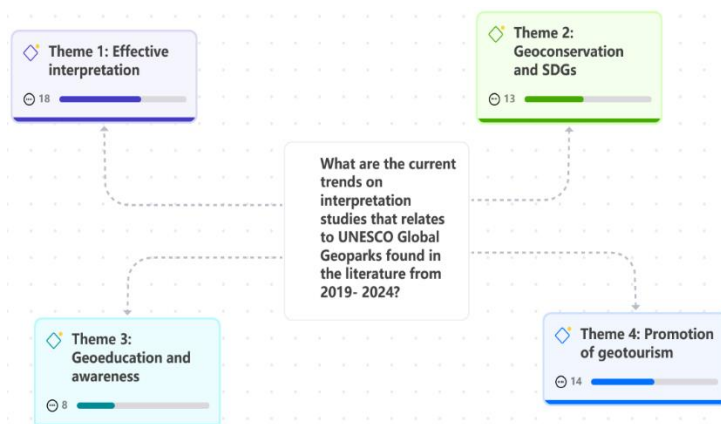


Figure 7 The themes used to answer RQ.

3.2.1. Theme 1: Effective interpretation

The theme of effective interpretation in Figure 8 is a crucial aspect of heritage and geotourism management, serving as a bridge between complex scientific concepts and the public understanding of geopark development. This report synthesizes findings from several studies that explore various approaches and strategies for effective interpretation within the context of geoparks, focusing on how these methods enhance visitor engagement, education, and conservation efforts.

Vegas et al. (2019) provided a comprehensive description of the standards for the design and presentation of interpretive panels under the administration of UNESCO in geoconservation and geotourism at geoparks (see Figures 8--6.2). The study shows examples of the formats of the interpretive panels in the Lanzarote and Chinijo Islands UNESCO Global Geoparks. The abiotic, biotic, and cultural interconnections (ABC) concept is a notable interpretive approach applied in the UNESCO Global Geoparks, such as the Colca and Volcanoes Andagua UNESCO Global Geopark in Peru and the Muroto UNESCO Global Geopark in Japan. While Pásková et al. (2021) commended the high level of ABC application in these two-ogeoparks, they identified significant gaps in the Colca and Volcanoes Andagua Geopark. Despite its potential, the latter relies heavily on the community's cultural integration, which may not be systematically structured or scientifically rigorous. This indicates a need for more structured frameworks and professional training to harness local enthusiasm effectively.

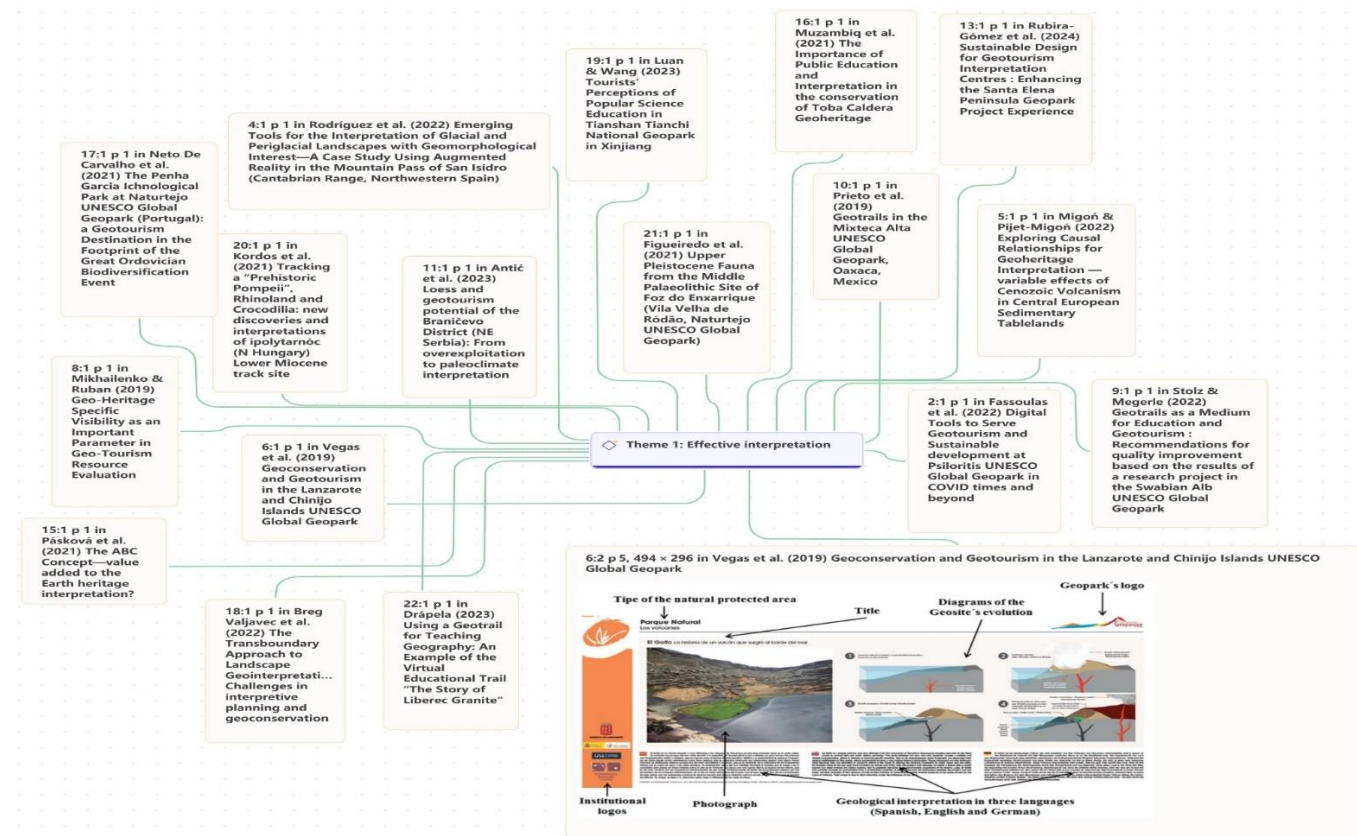


Figure 8 Theme 1 (Effective interpretation).

Community involvement in interpretive efforts is highlighted as crucial for effective interpretation. In the Toba Caldera Geoheritage Project, educational outreach increased the degree of understanding among residents and students from 11% to 67% (Muzambiq et al., 2021). However, this dramatic improvement raises questions about the baseline knowledge levels and the methods used to measure understanding. The long-term retention of this knowledge and its practical impact on conservation behaviors were not assessed, indicating a gap in evaluating the sustainability of educational interventions.

Digital tools and augmented reality (AR) have been developed to enhance geotourism experiences. Rodríguez et al. (2022) demonstrated the utility of AR in the interpretation of glacial and periglacial landscapes in the Cantabrian Range, Northwestern Spain, but the study stops short of addressing the accessibility and inclusivity of these technologies for all visitor demographics. In addition to enhancing the educational experience, the implementation of AR was consistent with the sustainable utilization of natural resources. Furthermore, Fassoulas et al. (2022) asserted that the Psiloritis UNESCO Global Geopark in Greece effectively implemented digital tools during the COVID-19 pandemic. However, the long-term efficacy of these tools in maintaining visitor engagement postpandemic has yet to be proven.

Geotrails are highlighted as vital resources for field education, yet many existing trials fail to engage a lay audience effectively. Rubira-Gómez et al. (2024) emphasized the need for well-designed geotrails that incorporate state-of-the-art didactic and touristic criteria. They recommended improvements such as integrating education for sustainable development (ESD) and utilizing new technologies to enhance the interpretive experience. Similarly, Drápela (2023) highlighted the importance of creating teaching materials and geotrails that are engaging and accessible for school-age children, promoting active participation and learning in field education.

Effective interpretation in geotourism and heritage management requires a multifaceted approach that includes the integration of scientific concepts with cultural and biotic elements, community involvement, and the use of emerging technologies. By adopting these strategies, geoparks and heritage sites can enhance visitor engagement, promote education, and support conservation efforts. The studies reviewed indicate that the visitor experience is not only enhanced but also that a greater appreciation for and commitment to the preservation of our natural and cultural heritage are fostered when interpretation is effectively implemented.

3.2.2. Theme 2: Geoconservation and SDGs

Geoconservation, the practice of preserving geological heritage, is intertwined with several of the UN's 17 Sustainable Development Goals (SDGs). Figure 9 shows that this theme examines the contributions and limitations of geoconservation efforts, as described in several articles, with a focus on their alignment with the SDGs related to education, tourism, community engagement, innovation, and environmental sustainability

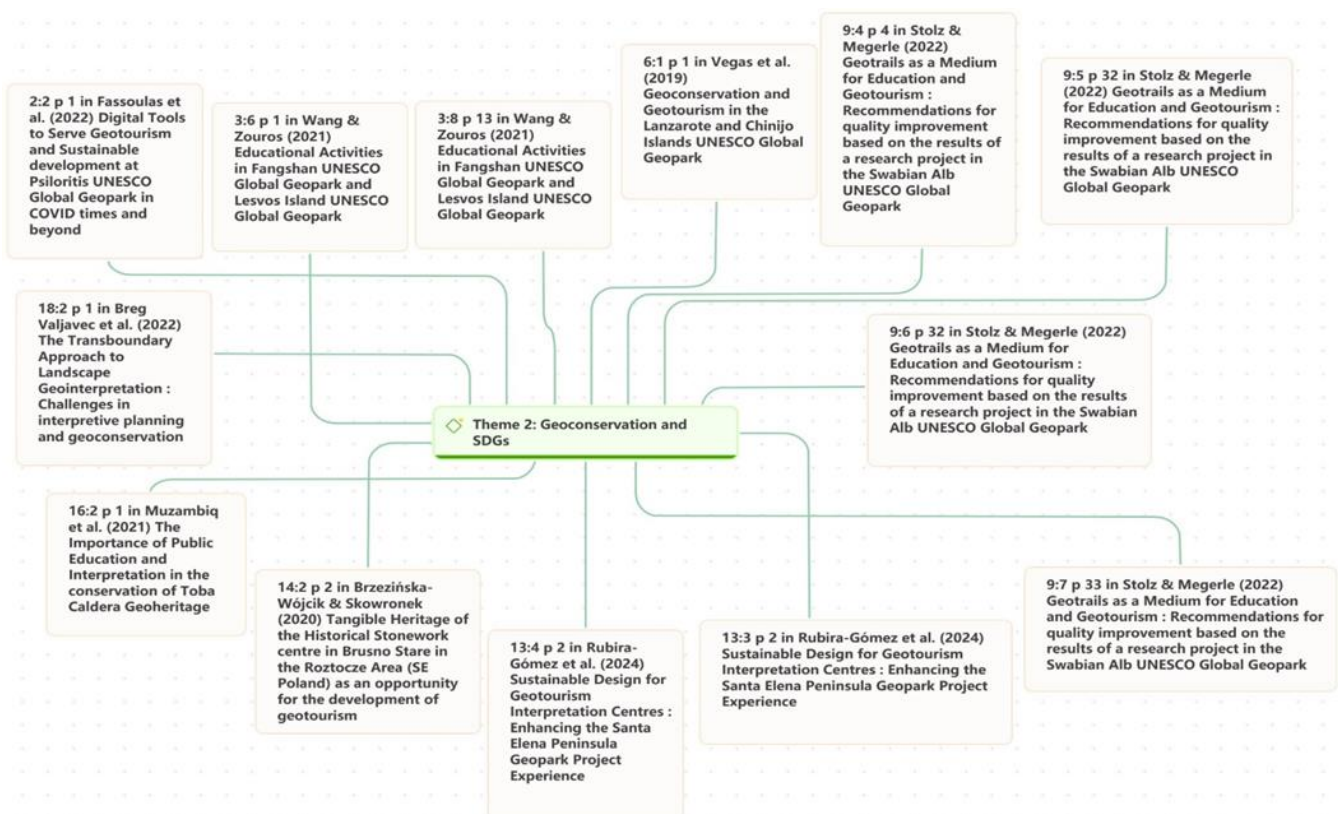


Figure 9 Theme 2 (Geoconservation and SDGs).

Geoeducation plays a vital role in fostering an understanding of geological heritage and its conservation. Stolz and Megerle (2022) underscore the importance of well-designed geotrails in the Swabian Alb UNESCO Global Geopark. They argued that these trails not only attract tourists but also serve as educational tools that enhance public understanding of geological phenomena through effective geointerpretation and the integration of new technologies. This aligns with SDG 4, which emphasizes inclusive and equitable quality education.

The Lanzarote and Chinijo Islands UNESCO Global Geopark Project, as discussed by Vegas et al. (2019), illustrates how geoconservation strategies can enhance the tourist experience by providing geological information and interpretation at key tourist sites. This approach not only improves the outreach of geoheritage but also contributes to the local economy by diversifying the touristic offer beyond traditional sun-and-beach tourism. Currently, geotourism, a niche tourism industry, is becoming more appealing to tourists and has the potential to stimulate economic development by fostering sustainable tourism practices and creating local jobs (Górska-Zabielska, 2023). This initiative contributes to the achievement of SDG 8, whose principal objectives include the promotion of sustained and inclusive economic growth coupled with full and productive employment for all members of society. However, sustainable geotourism must balance increased tourist influx with the preservation of geological sites. There is a risk that commercialization may overshadow conservation efforts, leading to potential degradation of the very resources these projects aim to protect (Vegas et al., 2019).

Rubira-Gómez et al. (2024) discuss the importance of engaging local communities in the design and operation of Geotourism Interpretation Centers (GICs) in the Santa Elena Peninsula Geopark. While community involvement is crucial for fostering a sense of ownership and cultural pride, ensuring that all community voices are heard and represented can also be challenging. Additionally, there is a need for sustainable financial models to maintain these centers in the long term without compromising their educational and cultural missions (Rubira-Gómez et al., 2024). This supports SDG 11, which focuses on making cities and human settlements inclusive, safe, resilient, and sustainable.

Fassoulas et al. (2022) highlighted the development of digital applications for the Psiloritis UNESCO Global Geopark, which enhances public engagement through interactive and immersive experiences. These tools enhance the interpretive infrastructure of the geopark and improve public engagement with geoheritage, aligning with SDG 9, which emphasizes building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation.

Geoconservation directly contributes to the protection of terrestrial ecosystems and the sustainable use of natural resources. Breg Valjavec et al. (2022) described a transboundary geoconservation approach in the karst landscapes of Slovenia and Croatia, emphasizing the importance of participatory workshops with local stakeholders. This collaborative model is essential for managing shared geological heritage. However, the effectiveness of such transboundary efforts can be hindered by differing national policies, funding limitations, and potential conflicts of interest among stakeholders. Ensuring sustained cooperation and adequate resource allocation remains a significant challenge (Breg Valjavec et al., 2022). The program aligns with the objectives outlined in SDG 15, focusing on the conservation and restoration of terrestrial ecosystems, sustainable forest management, mitigation of desertification, and reversal of land degradation processes.

Geoconservation is integral to achieving the UN's Sustainable Development Goals by fostering education, sustainable tourism, community engagement, innovation, and environmental protection. The studies and projects discussed in this review demonstrate how geoconservation practices can effectively contribute to multiple SDGs, highlighting the importance of integrated and multidisciplinary approaches in promoting sustainable development.

3.2.3. Theme 3: Geoeducation and awareness

Figure 10 illustrates the critical role of geoeducation in enhancing public awareness of geological heritage. It aims to engage and educate the public, fostering a deeper appreciation and understanding of geological phenomena (Catana & Brilha, 2020). This theme explores different geoeducation initiatives and their influence on knowledge and consciousness, drawing on contemporary research findings from academic sources.

The UNEO Global Geoparks are significant sites for geoeducation, offering diverse educational programs that leverage their geological, ecological, and cultural heritage. Wang and Zouros (2021) highlight the educational activities in Fangshan UNESCO Global Geopark and Lesvos Island UNESCO Global Geopark, emphasizing their collaboration with educational institutions to implement a diverse array of programs, field courses, and excursions. The importance of incorporating geoeducation into university curricula, which enables students to engage with geosites, is emphasized. Nevertheless, the efficacy of these initiatives is contingent upon a variety of variables, such as the pedagogical strategies employed and the level of collaboration between universities and geoparks. The results indicate that students' comprehension and admiration of geoheritage can be substantially improved through the implementation of customized educational activities. The Bohemian Paradise UNESCO Global Geopark (Migoń & Pijet Migoń, 2022) has further demonstrated through its practice that educational workshops developed on the basis of unique geological characteristics can effectively enhance participants' geological literacy and environmental conservation awareness.

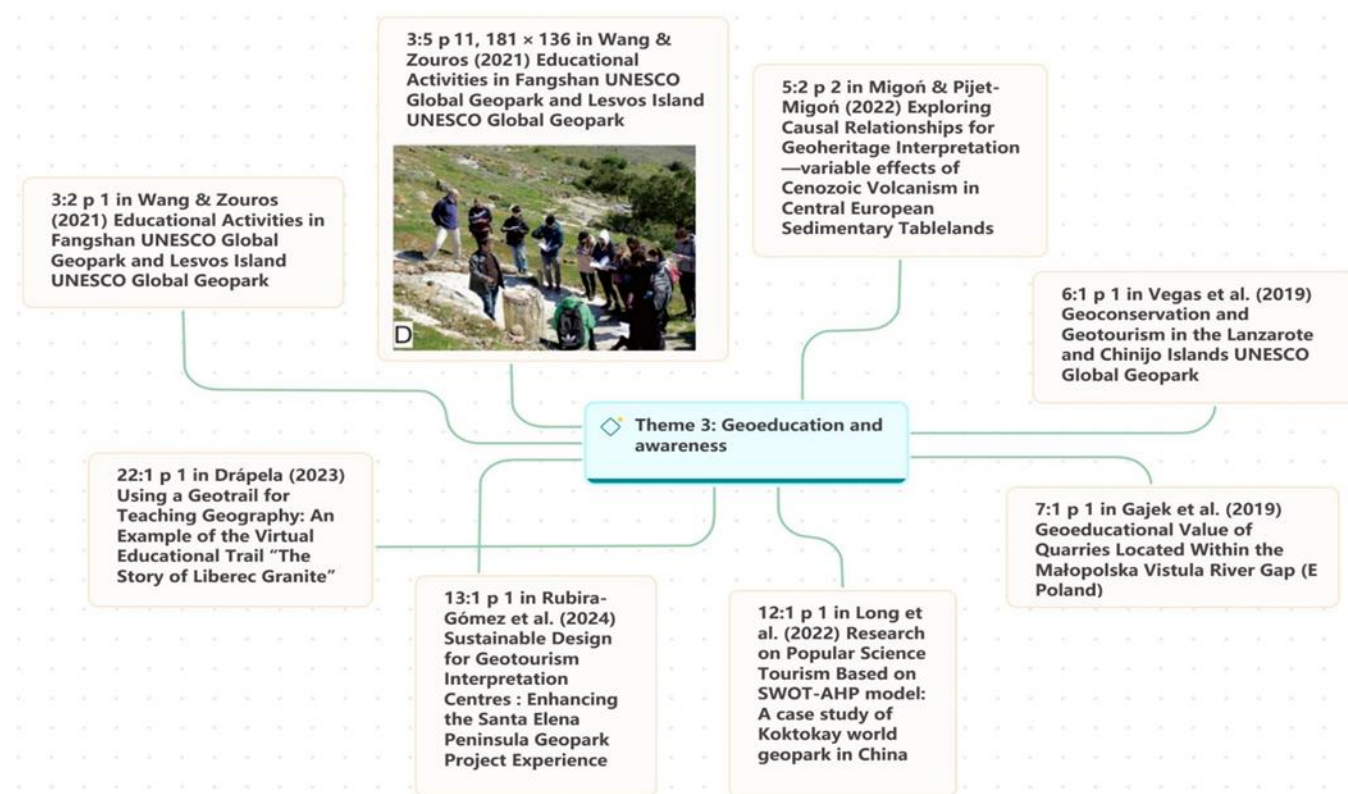


Figure 10 Theme 3 (Geoeducation and awareness).

Drápela (2023) investigated the potential of virtual geotrails, specifically "The Story of Liberec Granite," as educational resources for the study of natural history and geography. The study assesses the efficacy of this geotrail by conducting surveys and interviews with educators, thereby identifying the critical components that contribute to its success. The design of educational materials that are specifically designed for school-age children, the proximity to schools, and the incorporation of interactive tasks were identified as critical factors. The study underscores the necessity of actively engaging students in order for geotrails to be frequently employed and effective in field education rather than passively receiving information. This method not only improves the learning experience but also fosters a better understanding of geological phenomena.

The educational activities at UNESCO Global Geoparks also align with the Sustainable Development Goals (SDGs) (da Silva, 2020; UNESCO Global Geoparks, 2025). By fostering geoeducation, these geoparks contribute to several SDGs, as mentioned in theme 2, including quality education (SDG 4), sustainable cities and communities (SDG 11), and life on land (SDG 15). The integration of geoeducation into local communities promotes sustainable practices and environmental stewardship, further highlighting the importance of such initiatives. As discussed by Rubira-Gómez et al. (2024), the Santa Elena Peninsula Geopark Project in Ecuador aims to promote community development through geotourism and geoeducation. While geoeducation initiatives promote sustainable practices and environmental stewardship, their success is often limited by insufficient funding and a lack of long-term strategic planning (Vegas et al., 2019). For example, numerous geoparks depend on external funding and short-term initiatives, which can result in educational program discontinuities. To make a sustainable impact, it is imperative to prioritize the acquisition of long-term funding and the formulation of strategic plans that are consistent with both local requirements and the global SDGs.

Despite the successes of various geoeducation programs, significant challenges remain. One major issue is the disparity in the quality and accessibility of educational materials. There is a need for comprehensive, engaging, and contextually relevant resources that can be easily integrated into school curricula. Furthermore, the development and maintenance of effective geoeducation programs necessitate improved collaboration between educational institutions and geoparks. It is also imperative to conduct ongoing evaluations and modifications to educational programs to guarantee their continued relevance and efficacy. This entails the collection of feedback from educators and students, as well as the ongoing assessment of the long-term effects of these programs on the comprehension and appreciation of geological heritage among students (Gajek et al., 2019). The studies reviewed highlight the effectiveness of various geoeducation activities at UNESCO Global Geoparks. By incorporating geoeducation into environmental education, individuals can grasp the interconnectedness of abiotic and biotic factors in ecosystems, leading to a more holistic approach to environmental conservation (Zafeiropoulos et al., 2021). Recent studies indicate that innovative digital tools in geoeducation, particularly virtual reality (VR) reconstructions of paleoenvironments, gamified learning platforms using GIS data, and blockchain-based certification systems for geoheritage

sites, significantly enhance visitor engagement and knowledge retention at UNESCO Global Geoparks (Papadopoulou et al., 2025).

3.2.4. Theme 4: Promotion of geotourism

Geotourism, a form of natural area tourism that specifically focuses on geology and landscapes, offers significant potential for sustainable development. This review critically examines the promotion of geotourism through various initiatives and projects described in the provided articles, with an emphasis on their successes and challenges, as illustrated in Figure 11.

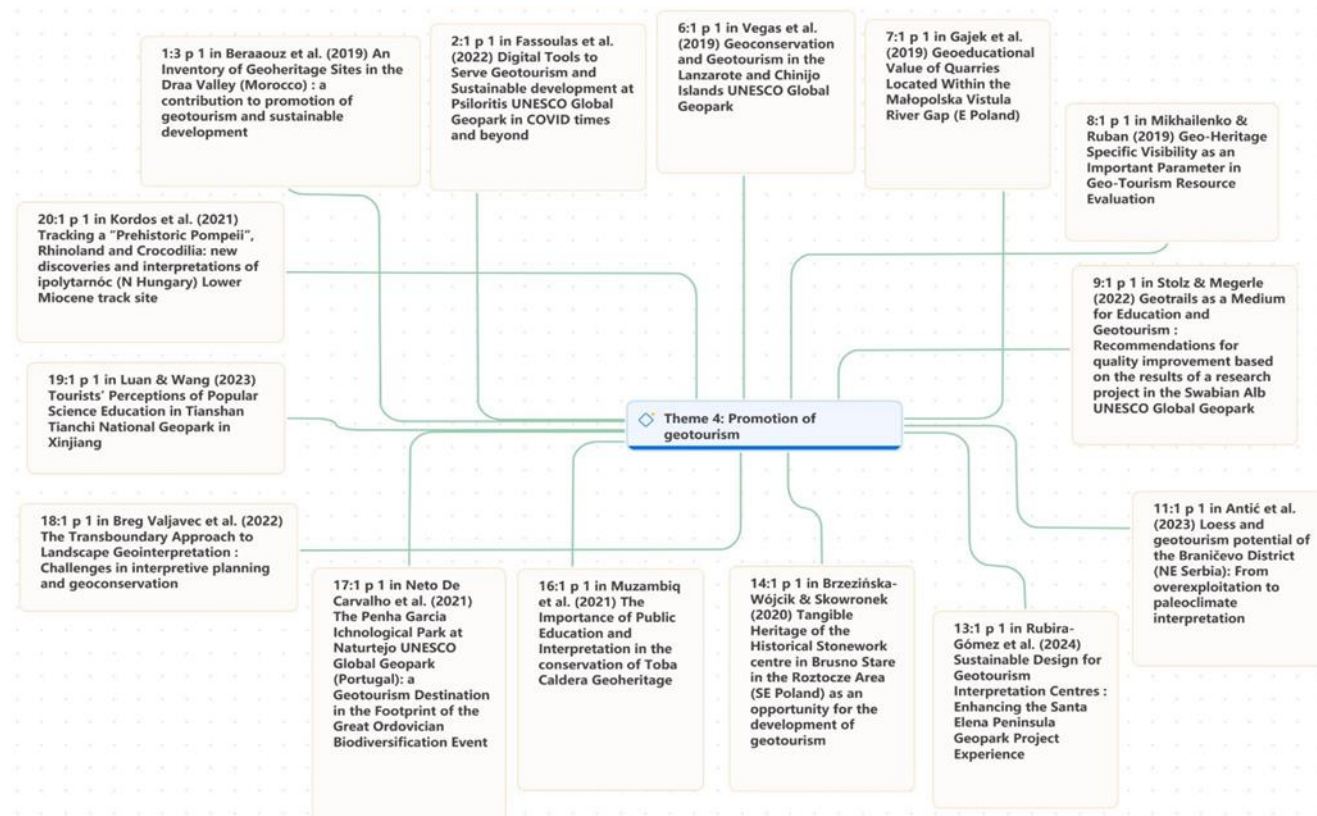


Figure 11 Theme 4 (Promotion of geotourism).

The assessment of loess profiles in Požarevac, northeastern Serbia, underscores their potential for geotourism, especially for paleoclimate interpretation (Antić et al., 2023). The modified geoheritage assessment model identifies these sites as exceptional geotourism locations. However, overexploitation and inadequate preservation measures pose significant risks to their sustainability. This study indicates that without stringent conservation efforts, the educational and tourism value of these sites may be compromised. The stonemasonry heritage of Brusno Stare in SE Poland offers another example of geotourism potential. By incorporating geological and historical interpretations, these sites can be developed into attractive cultural geosites. However, the abandonment of villages after World War II and the lack of promotion left these sites underutilized, highlighting the need for proactive preservation and marketing strategies (Brzezińska-Wójcik & Skowronek, 2020). The Penha Garcia Ichnological Park in Portugal is renowned for its significant fossil sites, which serve as prime geotourism destinations (Neto De Carvalho et al., 2021). Integrating scientific research with tourism has proven effective in attracting visitors and promoting education. However, balancing visitor access with the preservation of delicate fossil sites remains a significant challenge. Increased visitor traffic can lead to site degradation, necessitating stringent management practices. The application of digital tools such as virtual reality and story maps has emerged as a promising avenue for geotourism promotion. The Psiloritis UNESCO Global Geopark has utilized these tools to enhance the visitor experience and support sustainable development (Fassoulas et al., 2022). Despite their potential, the implementation of such technologies requires substantial investment and expertise. Additionally, there are concerns about digital accessibility, particularly for economically disadvantaged groups.

There are numerous obstacles to the promotion of geotourism, such as inadequate infrastructure, overexploitation of sites, and a lack of local engagement. To resolve these concerns, it is necessary to establish and maintain facilities that promote geotourism, thereby improving the visitor experience and ensuring its sustainability. Digital tools and educational programs should be incorporated to inform visitors about the significance of conservation and geoheritage. The most critical aspect is the participation of local communities in geotourism initiatives to guarantee cultural preservation and economic benefits.

Additionally, the management body should implement policies that ensure the conservation of geological and paleontological sites while simultaneously promoting tourism development.

4. Other Implications

The exploration of interpretation research on global geoparks reveals the implications of the sustainable development of geoparks in the future. A review of different interpretive applications further demonstrates the research involved in effective interpretation, geoconservation and SDGs, geoeducation and awareness, and the promotion of geotourism-related themes. The studies analyzed underscore the importance of effective interpretation in enhancing the understanding and appreciation of geoheritage. Migoñ and Pijet-Migoñ (2022) emphasize a holistic approach to geointerpretation, highlighting the interconnectedness of abiotic, biotic, and cultural elements in Central European geoparks. Similarly, Prieto et al. (2019) demonstrated how geotrails in the Mixteca Alta UNESCO Global Geopark engage visitors at various educational levels, bridging geological significance and societal value. These cases underline interpretation's essential role in deepening public connections with geoheritage. Closely linked to this, geoconservation aligns with the Sustainable Development Goals (SDGs) by preserving geoheritage while fostering sustainable development. Fassoulas et al. (2022) illustrated the use of digital tools in the Psiloritis UNESCO Global Geopark to maintain public engagement during the COVID-19 pandemic, ensuring accessibility and awareness despite global challenges. Similarly, Beraaouz et al. (2019) show how conserving geosites in Morocco's Draa Valley support education and sustainable tourism, contributing to local economic development. In addition to these efforts, geoeducation and geotourism play pivotal roles in promoting geological heritage. Wang and Zouros (2021) highlight university programs at Fangshan and Lesvos Island UNESCO Global Geoparks that enhance geological understanding, whereas Drápela (2023) reports on the virtual trail "The Story of Liberec Granite," which supports geography education. Furthermore, Rubira-Gómez et al. (2024) demonstrated how sustainable interpretation centers at the Santa Elena Peninsula Geopark advanced geoeducation and enriched visitor experiences. Collectively, these initiatives reflect the integrated role of interpretation, geoconservation, geoeducation, and geotourism in fostering public appreciation and ensuring the long-term preservation of geoheritage.

Furthermore, this study offers substantial insights into the diverse approaches and challenges associated with geoheritage interpretation, geoconservation, geoeducation, and the promotion of geotourism. The necessity of an integrative and multidisciplinary approach to effectively communicate the geological significance of geosites is a recurring theme. The multifaceted impacts of Cenozoic volcanism are illustrated by a three-tiered framework that connects landscapes, landforms, and individual outcrops, as proposed by Migoñ and Pijet-Migoñ (2022). This method not only increases visitor engagement but also emphasizes the importance of connecting geoscientific data with tangible, observable phenomena in geoparks. Further studies should concentrate on the refinement of these frameworks and the exploration of their applicability across various geological contexts with the goal of improving the interpretation of global geoheritage. Geoconservation efforts, as highlighted in these studies, must adapt to the evolving challenges posed by climate change and human activities. Digital tools have the potential to advance geoconservation and maintain public interest, as demonstrated by Fassoulas et al. (2022). These tools, which include interactive maps and virtual reality applications, have been demonstrated to be effective in the Psiloritis UNESCO Global Geopark and have the potential to be adapted for use in other geoparks worldwide. The long-term impact of these digital tools on conservation outcomes and the exploration of new technologies that could further enhance geosite protection and visitor education are areas that require further investigation in future research. Geoeducation remains a cornerstone of geopark initiatives, fostering a deeper understanding of geological processes and their relevance to sustainable development. Wang and Zouros (2021) emphasize the role of educational programs in UNESCO Global Geoparks, which have shown positive outcomes in terms of student engagement and learning. Nevertheless, it is imperative to conduct more thorough research that assesses the efficacy of these programs in a variety of cultural contexts and educational levels. Furthermore, it is imperative to continue the development and evaluation of innovative educational strategies, such as the virtual educational trail that Drápela (2023) discusses, for the purpose of expanding their potential to engage a broader audience and improve field education. The sustainable economic development of local communities and the preservation of geoheritage are both dependent on the promotion of geotourism. Rubira-Gómez et al. (2024) emphasized the importance of sustainable design in the promotion of geoeducation and the enhancement of the visitor experience. Further studies should investigate the socioeconomic consequences of these initiatives, with a particular emphasis on community engagement and local employment. Additionally, a more comprehensive approach to regional development and heritage conservation could be achieved through interdisciplinary research that integrates geotourism with cultural and historical tourism. By incorporating these diverse elements, future efforts may ensure that geotourism not only educates and entertains visitors but also substantially contributes to the sustainable management and conservation of geoheritage sites.

5. Final Considerations

This study significantly contributes to the research progress and comprehension of interpretation studies at the UNESCO Global Geoparks. This research offers a comprehensive overview of the integration of a variety of interpretation strategies into

geological conservation, UN Sustainable Development Goals, geoeducation and geotourism to promote the sustainable development of geoparks through the use of thematic reviews.

This study identifies and synthesizes current trends and patterns across a variety of geopark interpretation studies by employing a thematic review. This method enables researchers to observe the convergence of ideas and the emergence of key themes that emphasize sustainable practices and foster environmental awareness through its educational function. The thematic review emphasized the interconnectedness of various strategies and systems, offering a comprehensive comprehension of their collective contributions to sustainability objectives. Additionally, the thematic review method assists in identifying deficiencies in the literature and practice, thereby providing a direction for future research. By identifying recurring themes and areas of interpretation, this study offers a valuable reference for park policymakers, visitors, practitioners, and researchers who are interested in advancing practical practice. The insights obtained from this thematic analysis can be used to inform the development of new policies, guidelines, and the integration of digital and interactive technologies, including augmented reality (AR), virtual reality (VR), and mobile applications, which offer immersive and accessible visitor experiences.

In conclusion, this research provides a comprehensive thematic review of interpretation studies in UNESCO Global Geoparks, thereby making valuable contributions to the field. It reveals trends and patterns that underscore the importance of effective interpretation, geoconservation and SDGs, geoeducation and awareness, and the promotion of geotourism. These contributions are indispensable for the purpose of directing future research and practice in the direction of the sustainable development of geoparks.

Ethical Considerations

Not applicable.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Funding

This research did not receive any financial support.

References

- Antić, A., Radaković, M. G., Marjanović, M., Marković, S. B., Perić, Z. M., Spalević, V., ... & Tomić, N. (2023). Loess and geotourism potential of the Braničevo District (NE Serbia): From overexploitation to paleoclimate interpretation. *Open Geosciences*, 15(1), 20220546. <https://doi.org/10.1515/geo-2022-0546>
- Beraaouz, M., Macadam, J., Bouchaou, L., Ikenne, M., Ernst, R., Tagma, T., & Masrour, M. (2019). An inventory of geoheritage sites in the Draa Valley (Morocco): A contribution to promotion of geotourism and sustainable development. *Geoheritage*, 11(2), 241–255. <https://doi.org/10.1007/s12371-017-0256-x>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>
- Breg Valjavec, M., Dunato Pejnović, N., Draženović, M., Čonč, Š., & Polajnar Horvat, K. (2022). The transboundary approach to landscape geointerpretation: Challenges in interpretive planning and geoconservation. *Geoheritage*, 14(4), 116. <https://doi.org/10.1007/s12371-022-00751-3>
- Brzezińska-Wójcik, T., & Skowronek, E. (2020). Tangible heritage of the historical stonework centre in Brusno Stare in the Roztocze Area (SE Poland) as an opportunity for the development of geotourism. *Geoheritage*, 12(1), 10. <https://doi.org/10.1007/s12371-020-00442-x>
- Catana, M. M., & Brilha, J. B. (2020). The role of UNESCO global geoparks in promoting geosciences education for sustainability. *Geoheritage*, 12(1), 1. <https://doi.org/10.1007/s12371-020-00440-z>
- Cheng, Z., & Chen, X. (2022). The effect of tourism experience on tourists' environmentally responsible behavior at cultural heritage sites: The mediating role of cultural attachment. *Sustainability*, 14(1), 565. <https://doi.org/10.3390/su14010565>
- da Silva, E. M. R. (2020). *The contribution of the European UNESCO Global Geoparks for the 2030 Agenda for Sustainable Development – a study based on several data sources* (Doctoral thesis). Universidade NOVA de Lisboa, Portugal.
- de Freitas, I. V., & Koskowski, M. R. (2021). Heritage and sustainable development: Capacity building through tourism (1st ed.). In *Capacity Building Through Heritage Tourism* (pp. 113–131). Apple Academic Press.
- Dowling, R., & Newsome, D. (2018). *Handbook of geotourism* (1st ed.). Edward Elgar Publishing.
- Drápela, E. (2023). Using a geotrail for teaching geography: An example of the virtual educational trail “The story of Liberec granite”. *Land*, 12(4), 828. <https://doi.org/10.3390/land12040828>
- Fassoulas, C., Nikolakakis, E., & Staridas, S. (2022). Digital tools to serve geotourism and sustainable development at Psiloritis UNESCO Global Geopark in COVID times and beyond. *Geosciences*, 12(2), 78. <https://doi.org/10.3390/geosciences12020078>
- Figueiredo, S. D., Raposo, L., & Sousa, M. (2021). Upper Pleistocene fauna from the Middle Palaeolithic site of Foz do Enxarrique (Vila Velha de Ródão, Naturtejo UNESCO Global Geopark). *Geoconservation Research*, 4(2), 685–693. <https://doi.org/10.30486/gcr.2021.1912483.1048>
- Gajek, G., Zgłobicki, W., & Kołodzyńska-Gawrysiak, R. (2019). Geoeducational value of quarries located within the Małopolska Vistula River Gap (E Poland). *Geoheritage*, 11(4), 1335–1351. <https://doi.org/10.1007/s12371-019-00395-w>
- Global Geoparks Network International Association. (2024). *Actively participate in global challenges*. <https://www.visitgeoparks.org/our-missions>
- Górska-Zabielska, M. (2023). A new geosite as a contribution to the sustainable development of urban geotourism in a tourist peripheral region—Central Poland. *Resources*, 12(6), 71. <https://doi.org/10.3390/resources12060071>

- Gross, M. P., Zimmerman, R., & Buchholz, J. (2006). *Signs, trails, and wayside exhibits: Connecting people and places* (3rd ed.). Uw-Sp Foundation Press.
- Ham, S. (2013). *Interpretation—Making a difference on purpose* (1st ed.). Fulcrum Publishing.
- Hose, T. A. (2007). Geotourism: Appreciating the deep time of landscapes (1st ed.). In *Niche tourism* (pp. 27–37). Routledge.
- Kordos, L., Mészáros, I., & Szarvas, I. (2021). Tracking a “Prehistoric Pompeii”, Rhinoland and Crocodilia: New discoveries and interpretations of Ipolytarnóc (N Hungary) Lower Miocene track site. *Geoconservation Research*, 4(2), 621–634. <https://doi.org/10.30486/gcr.2021.1914158.1062>
- Liuzza, C. (2020). *UNESCO and the global responsibility for heritage preservation* (Doctoral thesis). Stanford University, Stanford, CA.
- Long, C., Lu, S., & Zhu, Y. (2022). Research on popular science tourism based on SWOT-AHP model: A case study of Koktokay World Geopark in China. *Sustainability*, 14(15), 8974. <https://doi.org/10.3390/su14158974>
- Luan, F., & Wang, F. (2023). Tourists’ perceptions of popular science education in Tianshan Tianchi National Geopark in Xinjiang. *Geoheritage*, 15(4), 120. <https://doi.org/10.1007/s12371-023-00886-x>
- Martini, G., Zouros, N., Zhang, J., Jin, X., Komoo, I., Border, M., ... & Sá, A. A. (2022). UNESCO Global Geoparks in the “World after”: A multiple-goals roadmap proposal for future discussion. *Episodes Journal of International Geoscience*, 45(1), 29–35. <https://doi.org/10.18814/epiugs/2021/021002>
- Mc Keever, P. J., & Zouros, N. (2005). Geoparks: Celebrating Earth heritage, sustaining local communities. *Episodes Journal of International Geoscience*, 28(4), 274–278. <https://doi.org/10.18814/epiugs/2005/v28i4/006>
- Migoñ, P., & Pijet-Migoñ, E. (2022). Exploring causal relationships for geoheritage interpretation—Variable effects of Cenozoic volcanism in Central European sedimentary tablelands. *Geoheritage*, 14(1), 9. <https://doi.org/10.1007/s12371-021-00637-w>
- Mikhailenko, A. V., & Ruban, D. A. (2019). Geo-heritage specific visibility as an important parameter in geo-tourism resource evaluation. *Geosciences*, 9(4), 146. <https://doi.org/10.3390/geosciences9040146>
- Morante-Carballo, F., Apolo-Masache, B., Taranto-Moreira, F., Merchán-Sanmartín, B., Soto-Navarrete, L., Herrera-Franco, G., & Carrión-Mero, P. (2023). Geo-environmental assessment of tourist development and its impact on sustainability. *Heritage*, 6(3), 2863–2885. <https://doi.org/10.3390/heritage6030153>
- Muzambiq, S., Walid, H., Ganie, T. H., & Hermawan, H. (2021). The importance of public education and interpretation in the conservation of Toba Caldera Geoheritage. *Geoheritage*, 13(1), 3. <https://doi.org/10.1007/s12371-020-00523-x>
- Necheş, I. M. (2016). Geodiversity beyond material evidence: A geosite type based interpretation of geological heritage. *Proceedings of the Geologists’ Association*, 127(1), 78–89. <https://doi.org/10.1016/j.pgeola.2015.12.009>
- Neto De Carvalho, C., Baucon, A. N., Bayet-Goll, A. N., & Belo, J. N. (2021). The Penha Garcia Ichneological Park at Naturtejo UNESCO Global Geopark (Portugal): A geotourism destination in the footprint of the Great Ordovician biodiversification event. *Geoconservation Research*, 4(1), 70–79. <https://doi.org/10.30486/gcr.2021.1913338.1051>
- Ólafsdóttir, R. (2019). Geotourism. *Geosciences*, 9(1), 48. <https://doi.org/10.3390/geosciences9010048>
- Papadopoulou, E. E., Kavroudakis, D., Agelada, A., Zouros, N., Soulakellis, N., & Kasapakis, V. (2025). Virtual reality in geoeducation: The case of the Lesvos Geopark. *Interactive Learning Environments*, 33(2), 1653–1669. <https://doi.org/10.1080/10494820.2024.2374399>
- Pásková, M., Zelenka, J., Ogasawara, T., Zavala, B., & Astete, I. (2021). The ABC concept—Value added to the Earth heritage interpretation? *Geoheritage*, 13(2), 1–25. <https://doi.org/10.1007/s12371-021-00558-8>
- Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Sage Publications, Inc.
- Prieto, J. L. P., de Castro Martínez, G. F., & González, E. M. R. (2019). Geotrails in the Mixteca Alta UNESCO Global Geopark, Oaxaca, Mexico. *Cuadernos Geográficos*, 58(2), 111–125.
- Reynard, E., & Briha, J. (2017). *Geoheritage: Assessment, protection, and management* (1st ed.). Elsevier.
- Rodríguez, C., Sevilla, J., Obeso, Í., & Herrera, D. (2022). Emerging tools for the interpretation of glacial and periglacial landscapes with geomorphological interest—A case study using augmented reality in the Mountain Pass of San Isidro (Cantabrian Range, Northwestern Spain). *Land*, 11(8), 1327. <https://doi.org/10.3390/land11081327>
- Rubira-Gómez, G., Malavé-Hernández, J., Jaya-Montalvo, M., Candell-Soto, J., Caicedo-Potosí, J., Merchán-Sanmartín, B., ... & Morante-Carballo, F. (2024). Sustainable design for geotourism interpretation centres: Enhancing the Santa Elena Peninsula Geopark project experience. *Heritage*, 7(1), 499–516. <https://doi.org/10.3390/heritage7010024>
- Singh, R. B., Wei, D., & Anand, S. (2021). *Global geographical heritage, geoparks and geotourism* (2nd ed.). Springer Nature Singapore.
- Stolz, J., & Megerle, H. E. (2022). Geotrails as a medium for education and geotourism: Recommendations for quality improvement based on the results of a research project in the Swabian Alb UNESCO Global Geopark. *Land*, 11(9), 1422. <https://doi.org/10.3390/land11091422>
- Tilden, F. (1957). *Interpreting our heritage: Principles and practices for visitor services in parks, museums, and historic places* (1st ed.). University of North Carolina Press.
- UNESCO Global Geoparks. (2024). *UNESCO International Geoscience and Geoparks Programme*. <https://www.unesco.org/en/igpp/geoparks/about>
- UNESCO Global Geoparks. (2025). *Development and conservation*. Global Geoparks Network. <https://www.visitgeoparks.org/missions>
- Vegas, J., Galindo, I., Romero, C., Sánchez, N., Díaz, G. A., Martín-González, E., & Mateo, E. (2019). Geoconservation and geotourism in the Lanzarote and Chinijo Islands UNESCO Global Geopark (1st ed.). In *Lanzarote and Chinijo Islands Geopark: From Earth to Space* (pp. 99–108). Springer, Cham.
- Veverka, J. (2015). *Interpretive master planning: Strategies for the new millennium—Philosophy, theory and practice* (1st ed.). Museums.
- Wang, J., & Zouros, N. (2021). Educational activities in Fangshan UNESCO Global Geopark and Lesvos Island UNESCO Global Geopark. *Geoheritage*, 13(3), 51. <https://doi.org/10.1007/s12371-021-00570-y>
- Xu, K., & Wu, W. (2022). Geoparks and geotourism in China: A sustainable approach to geoheritage conservation and local development—A review. *Land*, 11(9), 1493. <https://doi.org/10.3390/land11091493>
- Zafeiropoulos, G., Drinia, H., Antonarakou, A., & Zouros, N. (2021). From geoheritage to geoeducation, geoethics and geotourism: A critical evaluation of the Greek region. *Geosciences*, 11(9), 381. <https://doi.org/10.3390/geosciences11090381>
- Zairul, M. (2023). *Thematic review template* (Patent No. CRLY2023W02032). Controller of Copyright.
- Zairul, M., & Mohd Zairul. (2020). A thematic review on student-centred learning in the studio education. *Journal of Critical Reviews*, 7(2), 504–511. <https://doi.org/10.31838/jcr.07.02.95>
- Zairul, M., Azli, M., & Azlan, A. (2023). Defying tradition or maintaining the status quo? Moving towards a new hybrid architecture studio education to support blended learning post-COVID-19. *Archnet-IJAR: International Journal of Architectural Research*, 17(3), 554–573. <https://doi.org/10.1108/ARCH-11-2022-0251>