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Mini Review

Multidisciplinarity in Geoscientific Research

Olívia Maria Cordeiro de Oliveira[1]*, Antônio Fernando de Souza Queiroz[1], Ícaro Thiago Andrade Moreira[1], Karina dos Santos Garcia[1], José Roberto Cerqueira[1], Aristides Pavani Filho[1] and Agostinho Gomes Cascardo[2]

[1]Postgraduate Program in Geochemistry, Petroleum and Environment (POSPETRO), Institute of Geosciences, Federal University of Bahia, Brazil

[2]Open University, PhD in Social Sustainability and Development, Lisbon, Portugal

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***Corresponding author:** Olívia Maria Cordeiro de Oliveira, Postgraduate Program in Geochemistry, Petroleum and Environment (POSPETRO), Institute of Geosciences, Federal University of Bahia, Brazil, E-mail: copesq@ufba.br

ORCiD: https://orcid.org/0000-0002-8945-3000

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Abstract

The multidisciplinary approach of geoscientific research in the academic setting underscores the increasing necessity of integrating diverse fields of knowledge to tackle complex interconnected issues. This multidisciplinary field seeks to uncover the complex operations of the Earth, encompassing the analysis of its past movements of tectonic plates, historical climates, and valuable natural resources like minerals and hydrocarbons. In this context, geospatial intelligence plays a crucial role by enabling the effective analysis and interpretation of extensive geographic datasets, thus enhancing our understanding of environmental dynamics. Nevertheless, advancements in technology, globalization, and the difficulties posed by environmental and climatic transformations demand an even more profound collaboration among various disciplines, facilitating an expansive viewpoint and yielding more holistic solutions to contemporary predicaments.

Geosciences as an interdisciplinary field

Geosciences is not a discipline but a set of disciplines [1] with its focus and scientific investigation methodology. However, these disciplines: Geology, geophysics, geography, oceanography, meteorology, and environmental sciences do not work in isolation. As highlighted by [2], the complexity of Earth systems arises from interdependent elements across disciplines, necessitating an integrative approach to understand emergent behaviors and irreversible processes effectively within both natural and social contexts. The collaboration between distinct fields is fundamental for understanding complex phenomena such as plate tectonics, global warming, and water resource management. The multidisciplinary approach in field courses not only enlarges students' understanding of the subject but also enhances their ability to think critically and reflect on their learning processes, thus promoting cognitive and metacognitive development [3].

In this analytical framework, the phenomenon of interdisciplinarity emerges not merely from the necessity to elucidate the processes governing the Earth, but also from the intricate interrelations that transpire between these processes and human activities. For example, the initiative to address climate change requires the synergistic collaboration of social scientists, economists, engineers, and specialists in public policy, alongside traditional geoscientists. Modern geoscience requires a holistic approach to effectively address the complexities of natural disasters, integrating human impacts and advanced technologies for accurate prediction and effective mitigation strategies [4]. This underscores the paramount importance of integrating various disciplines to improve our comprehension and guardianship of the planet.

This review demonstrates the importance of synthesizing knowledge from multiple disciplines to address complex scientific themes and their challenges. This integration is

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crucial for developing innovative solutions that efforts within a discipline might overlook.

This paper aims to demonstrate that geosciences represent a multidisciplinary approach that shows the interconnections among various fields of knowledge, including emerging technologies and social sciences, to enhance our capacity to address urgent environmental challenges.

Collaboration between geosciences and emerging technologies

In recent years, technological advancements have significantly reshaped geoscientific research [5]. Tools like remote sensing [6], big data analytics [7], drones [6], artificial intelligence [8], and advanced computational modeling have become indispensable for geoscientists. Effectively integrating these technologies necessitates close collaboration across computer engineering, statistics, data science, and geography disciplines. The processing of large real-time data sets enhances understanding of complex Earth systems, enabling detailed observations and analyses that support multidisciplinary research and improve predictive modeling of environmental changes [9].

The deployment of comprehensive data analytics and artificial intelligence, for example, enables the modeling of climatic events [10], the prediction of geological occurrences such as earthquakes [11] and tsunamis [12], and the management of natural resources with unparalleled precision [13-14]. However, efficiently applying these technologies requires a synergistic collaboration among data scientists, engineers, and geoscientists. Collaborative efforts with technological disciplines enhance data integration, improve model scalability, and facilitate the development of advanced predictive models, addressing the inherent complexity of geoscientific data [15].

A prime example of multidisciplinary integration is using drones and remote sensors to monitor volcanic activity and tectonic plate movements. Geologists and geophysicists work alongside engineers and sensor technology experts to gather data from remote or inaccessible areas. These technologies deliver real-time information, aiding in disaster prevention and saving lives [16,17].

Geospatial intelligence has emerged as an essential asset in geoscientific investigations, allowing for the effective analysis and interpretation of extensive geographic datasets [18]. By employing sophisticated data processing methods, including machine learning and predictive modeling, geospatial intelligence aids in uncovering intricate patterns that may not be apparent through conventional approaches [19]. This methodology not only improves the capability to forecast geological and climatic phenomena [20] but also fosters the responsible management of natural resources by offering comprehensive insights into land use [21] and hydrology [20].

Geosciences and the social sciences

In addition to its connections with the exact sciences and technology, geoscientific research in academic settings increasingly requires collaboration with the social sciences. Global environmental changes, such as climate change, desertification, and natural disasters, have significant impacts on human society. How populations respond to these challenges, through public policy, infrastructure development, or cultural adaptation, is becoming an area of growing interest within geosciences. Effective governance informed by multidisciplinary science enhances resilience by integrating diverse knowledge, enabling communities to adapt to climate impacts and manage disaster risks effectively [22].

This collaboration is particularly evident in the domain of human geography, which investigates the interplay between human populations and their natural surroundings. Understanding socio-environmental dynamics is crucial for crafting responsive public policies that integrate local self-organization and formal governance, ensuring effective management of resources like water amid rapid environmental changes [23]. This underscores how the synergy between geosciences and social sciences can yield more comprehensive solutions to intricate problems.

Geosciences and the health sciences

The interrelationship between geosciences and health sciences has garnered heightened importance, especially for the impacts of environmental alterations on public health outcomes. Research shows that air, water, and soil quality directly influence respiratory diseases and waterborne illnesses through pollutants that induce lung inflammation and spread pathogens, highlighting the critical role of environmental health [24]. For instance, medical geology investigates how heavy metals in soil can accumulate in crops, leading to human exposure that increases cancer and cardiovascular disease risks due to their carcinogenic and co-carcinogenic properties [25]. Moreover, studies highlight that temperature significantly influences dengue incidence, indicating climatology's role in understanding climate change's impact on infectious diseases in tropical regions [26]. This collaboration between geosciences and health sciences is crucial for formulating preventive strategies and public policies aimed at reducing health risks in regions impacted by natural disasters and environmental degradation.

Challenges and opportunities of multidisciplinary research

While multidisciplinarity presents many benefits, such as the ability to tackle problems in a more comprehensive and integrated way, it also comes with considerable challenges. One of the main difficulties is the communication between disciplines that frequently employ different languages and methodologies. Additionally, establishing multidisciplinary teams necessitates effective coordination and a clear understanding of shared objectives.

Institutional impediments, such as restrictive departmental structures and insufficient resources, alongside cultural barriers like differing disciplinary languages, hinder effective interdisciplinary collaboration and integration in higher

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education [27]. However, as global issues such as climate change and resource depletion become increasingly urgent, the necessity for a multidisciplinary approach to geoscientific research is needed. This demands the creation of a more adaptable and cooperative academic environment in which the boundaries between distinct disciplines can be transcended.

While multidisciplinary research offers significant advantages, the incorporation of geospatial intelligence brings forth various challenges. A primary issue is the diversity of terminologies and methodologies utilized across different disciplines, which can obstruct effective communication and teamwork among experts. Additionally, the requirement for specialized technical skills to adeptly use geospatial tools may pose barriers for researchers who do not possess this knowledge. Nevertheless, tackling these challenges also creates valuable opportunities. By cultivating an environment that encourages interdisciplinary cooperation and providing targeted training programs, research teams can enhance their skill sets, leading to groundbreaking solutions for complex environmental challenges. By integrating geospatial intelligence, researchers can make better-informed decisions and develop more effective strategies for sustainable resource management.

Conversely, the potential for innovation and discovery that emerges from collaboration across different fields of knowledge is substantial. Integrating diverse expertise fosters creative problem-solving, enabling teams to approach complex challenges from multiple perspectives, leading to innovative solutions that single-discipline efforts may overlook [28].

Conclusion

Geoscientific inquiry within the academic milieu is perpetually advancing, driven by the necessity for a comprehensive interdisciplinary methodology. Synergistic efforts among geosciences, innovative technological developments, and social sciences possess the capacity to transform our comprehension of the Earth and augment our ability to address pressing global environmental issues.

Although the facilitation of communication and the integration of various academic disciplines persist as notable obstacles, the potential benefits afforded by multidisciplinary research are considerable. The ability to synthesize knowledge from diverse fields is imperative for the progression of scientific inquiry and for devising efficacious responses to the complexities of the 21st century.

Geoscientific research is continually evolving in response to the pressing need for a comprehensive interdisciplinary approach. The collaboration among geosciences, emerging technologies, and social sciences has the potential to transform our understanding of the Earth and enhance our capacity to address urgent environmental issues. In this context, geospatial intelligence emerges as an essential tool, empowering researchers to analyze complex data effectively and identify critical patterns that can inform sustainable decision-making. As we confront the challenges of the 21st century, such as climate change and environmental degradation, the integration of geospatial intelligence into multidisciplinary research will be vital for developing innovative and adaptive solutions. Therefore, fostering greater collaboration and training in geoinformation is imperative for achieving a sustainable future.

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