Zonia Baber's pioneering role in the evolution of Geoscience Education

Annachiara Rosati[1], Luisa Sabato[1] & Marcello Tropeano[1]

[1]Dipartimento di Scienze della Terra e Geoambientali, Università di Bari Aldo Moro, Via Edoardo Orabona 4, 70125, Bari.

AR, 0009-0001-5704-3971; LS, 0000-0001-5101-1488; MT, 0000-0002-8942-9190.

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Short note

Corresponding author e-mail: annachiara.rosati@uniba.it

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ABSTRACT

Zonia Baber (1862–1956) emerges among pioneering figures in geosciences as an innovative influence, bridging disciplinary boundaries and exemplifying how geosciences can serve as a vehicle to address complex social, cultural, and environmental issues. Baber's contributions present an opportunity to critically reassess the field's pedagogical and ethical frameworks while underscoring its inherently interdisciplinary nature. As a professor of geography and geology at the University of Chicago and other institutions at all educational levels, Baber challenged the rigid and exclusionary frameworks of her time demonstrating resilience, creativity, and intellectual foresight. This article delves into her keen teaching philosophy and practices, offering a compelling reflection on her enduring impact on the evolution of geoscience pedagogy.

KEYWORDS: history of geosciences, women in geosciences, geoscience education, interdisciplinary education, experiential learning.

INTRODUCTION AND HISTORICAL CONTEXT

In the late 19th and early 20th centuries, geoscience education was rooted in rote memorisation and abstract learning, with geology limited to basic, technical topics and geography focusing on static maps, often isolated from broader societal and environmental contexts; while geology served industrial needs, geography struggled for academic legitimacy. Within this framework, the American teacher of geology and geography Mary Arizona (known as Zonia) Baber, active between the late 19th and mid -20th centuries, started to question these traditional models. She rejected the notion of knowledge as a series of isolated disciplines, advocating instead for an interconnected view of learning. A crucial point raised by Baber's work is if geosciences are not inherently transcultural, transdisciplinary, and interrelated. This question's affirmative response draws attention to a more fundamental systemic problem: why do modern geoscience curricula so frequently fall short in incorporating these features into teaching? Through her novel teaching philosophy and fearless support of a geoscience education that prioritised inclusivity, engagement, and societal relevance, Zonia Baber confronted this deficiency head-on. It is essential to place Baber's efforts amid the larger sociopolitical and cultural changes of her day in order to properly appreciate the significance of her life's work.

She was born in 1862 and lived through some of the most tumultuous and revolutionary times in contemporary history until her death in 1956. She witnessed the aftermath of the American Civil War (1861–1865), the rapid industrialisation of the late 19th century and the profound global reconfigurations prompted by the two World Wars (1914–1918; 1939–1945). In the United States, slavery had been formally abolished through Lincoln's Emancipation Proclamation of 1863; however, this legislative cornerstone neither eradicated racism nor ended racial segregation. On the contrary, the 19th and 20th centuries were marked by pervasive violence, characterised by protests, uprisings, and brutal acts of racial terror. Across America — and indeed throughout the world — individuals labelled as belonging to ethnic minorities were subjected to unspeakable atrocities, while systematically stripped of their rights, dignity, and humanity. All of this marked a period of immense change, as this era was also characterised by entrenched social hierarchies and pervasive colonialism. The expansion of American

imperialism — evident in territorial acquisitions like Hawaii and the Philippines — coincided with the height of European colonial endeavours, as educational institutions became vehicles for justifying and perpetuating imperialist ideologies. By incorporating exclusionary narratives into textbooks and curricula and sustaining pseudoscientific defences of colonialism, slavery, and segregation, these corrupted paradigms spread into scientific disciplines, including the geosciences. Women in this environment encountered structural obstacles to engage in scientific research. For female educators, geography provided a unique access point. Learning opportunities were similarly denied to the lower social classes, not only at higher levels of education but even at its most basic stages. Families living in poverty were frequently unable to afford schooling for their children, and they were largely forced into labour from an early age; this period, marked by the widespread abuse of child labour, saw some of the highest levels of such practices in history. On the other hand, geology continued to be dominated by men, chiefly those from the wealthiest and most privileged social classes, and primarily focused on resource exploitation to validate social stratification: economically dominant nations, driven by industrial ambition and unrelenting greed, systematically plundered the less developed yet resource-rich countries, entrenching poverty and reinforcing systems of oppression; consider, for instance, the South African diamond mines, where local labourers suffered from cruel and torturous working conditions. The teaching of geoscience had thus been profoundly compromised, propagating a perilous instruction imbued with themes of hatred and violence. Zonia Baber did not hesitate to critique these distortions openly, both through her contributions to scientific journals and during her lectures: an audacious and highly uncommon stance for her time.

THE LIFE AND EDUCATIONAL PHILOSOPHY OF ZONIA BABER

Mary Arizona Baber was born on August 24, 1862, into a farming family in Kansas, Illinois. During her childhood, her fascination with geology and geography began to take root through her explorations of the agricultural landscape surrounding her family's farm (Schultz & Hast, 2001). She attended a nearby country school, and her desire to further her education led her to leave home and move in with an uncle in Paris, Illinois, where she completed her high school studies in 1882. During this time, she adopted the name "Zonia", which she carried throughout her life. She briefly taught at a local county school before pursuing higher education at the Cook County Normal School (CCNS) of Englewood, Illinois, graduating in 1885. Normal Schools were institutions designed to train educators, attended by those who could not afford university education, as well as women, who were not yet admitted to universities. Baber's time there was transformative: under the guidance of Colonel Francis Wayland Parker — today recognised as one of the founding figures, alongside John Dewey, of the American progressive education movement — she embraced the modernistic pedagogical approach that focused on the individuality of each student's learning path. This method, which rejected rote memorisation in favour of active, experiential learning, strongly influenced her future teaching career. Parker's commitment to hands-on learning aligned perfectly with Baber's passion for geology, geography and fieldwork. Their professional and personal relationship, strengthened by mutual respect, would become a milestone of her educational philosophy (Schultz & Hast, 2001).

Following her graduation, Baber's career took her to Youngstown, Ohio, where she served as principal of the Hillside Street School from 1886 to 1887. She soon returned to CCNS, where, in 1889, she was appointed head of the Department of Geography, a position she held until 1899. It was here that Baber's unprecedented contributions to geoscience education began to take shape.

Women were still not allowed to teach or study at the highest levels of education. That started to change, though, in 1895, a turning point when American universities began to progressively admit women and let them pursue scientific fields previously precluded to them. It was in this transformative context that, in the same year, Baber enrolled at the University of Chicago and attended the first geology course offered to women (Fig. 1).

In 1896, she also created and patented a desk for the active study of the geosciences: school desks had only been invented relatively recently, around 1880, and were still highly uncomfortable. Her resourceful desk design enabled the continuous storage of all materials required for the courses, while also providing an appropriate inclination to support proper posture (Baber, 1896) (Fig. 2).

At the core of her idea lies a box-shaped desktop that is designed to house a shallow metallic tray, ideally made of galvanised iron, which could be filled with sand for immediate modelling activities.

Fig. 1 - Zonia Baber gathering fossils at Mazon Creek, Illinois, 1895. The summer class in Geology, taught by Thomas C. Chamberlin, was the first field class at the University of Chicago to which women were admitted (University of Chicago Photographic Archive, [apf1-00303], Hanna Holborn Gray Special Collections Research Center, University of Chicago Library).

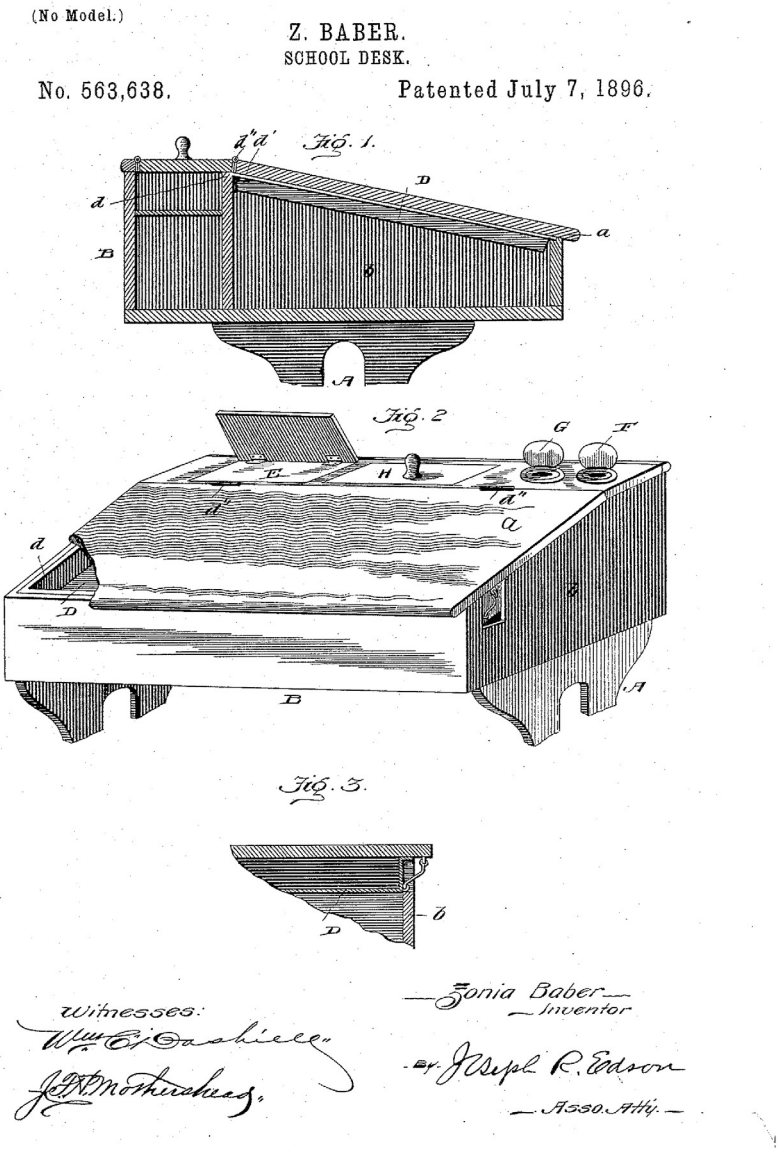

Fig. 2 - Original drawing of Zonia Baber's patented school desk (Baber, Zonia. School desk, Patent No. US563638, United States Patent Office, July 7, 1896).

This tray was not an auxiliary item but rather an integral component of the desk structure: it was designed to rest snugly within a recessed ledge at the top of the desk, allowing its surface to remain level and stable during use. The tray could either be removed entirely for cleaning or manipulation, or else hinged to the desk lid, enabling it to rise in unison with the cover when lifted. This clever mechanism allowed for easy access without disturbing the contents within. The dual functionality of the tray ensured that students could seamlessly alternate between writing and experimental work without disrupting their workspace's physical arrangement. Beyond this central feature, Baber's desk also incorporated additional compartments tailored to the requirements of practical science instruction. Behind the main lid, a dedicated cavity provided storage for clay, used in moulding exercises. Adjacent to this were carefully positioned wells for ink, water, and writing implements. This layout ensured that all necessary tools for both creative and academic activities were always readily accessible.

Baber's invention addressed a clear pedagogical need: to eliminate the logistical delays and spatial constraints that often hindered experiential learning in schools. Her design thus emerges as a compelling synthesis of functionality and educational foresight, integrating practical features that transformed the classroom into an interactive learning environment. By embedding compartments and tools directly into the structure of the desk, she created a didactic apparatus that embodied the principles of active learning well before such methodologies became mainstream.

Baber and Parker's alternative pedagogical methods, though praised by many as revolutionary, provoked considerable criticism from the governmental authorities overseeing the CCNS (Schultz & Hast, 2001). Amidst mounting financial pressures, the city of Chicago took over management of the school in 1896. Renamed the Chicago Normal School, the institution persisted in its mission to advance educational innovation, yet remained a focal point of contention. In 1899, Baber left the Chicago Normal School following Parker's resignation to lead the newly established Chicago Institute of Pedagogy, a privately funded institution free from political interference. The Institute encompassed both teacher training and a demonstration school for children. In 1901,

William Rainey Harper, president of the University of Chicago, invited Parker to integrate the Chicago Institute with John Dewey's Laboratory School to form the University's School of Education (Schultz & Hast, 2001). Again, Baber hence followed Parker to the University of Chicago, where she was appointed Associate Professor of Geography and Geology in July 1901. In 1902, she became principal of the School of Education for one year, while pursuing a Bachelor of Science degree, which she obtained in 1904. She led the University's department of Geography and Geology until 1921 (Ogilvie & Harvey, 2000) and was noted for the quality of her geology curriculum (Bailey, 1994). She retired from the University of Chicago in 1921, following her own decision, due to a physical disability resulting from an automobile accident (Pittser, 1999). Even though physically limited, she continued to write academic papers, give influential seminars, and participate in international conferences and assemblies. She played a key role in planning and presiding over professional meetings for the societies she founded or was an active member of, such as the Geographic Society of Chicago, which she founded in 1898, or the Chicago Woman's Club and the Wild Flower Preservation Society, which she co-founded. Throughout her life, Baber courageously defied the political and societal conventions of her time, dedicating herself to dismantling racial prejudice and imperialist supremacy, and voicing for human rights and women's emancipation. As leader of the Race Relations Committee of the Chicago Women's Club and a member of the executive committee of the National Association for the Advancement of Coloured People (NAACP) in Chicago, she was a vocal proponent of Civil Rights. In 1926, she actively supported the extension of women's suffrage in Puerto Rico. In the same year, she was among the six Women's International League for Peace and Freedom (WILPF) members of the Balch Mission to Haiti, an initiative instrumental in bringing an end to the United States' military occupation of the country. An early advocate for environmental preservation, she also campaigned to establish the Indiana Dunes National Park. As chairwoman of the WILPF, Baber headed efforts to reform educational materials, favouring the removal of outdated and culturally biased language that reinforced harmful stereotypes. Her extensive travels enriched her teaching, as she inspired students to value the richness and beauty of the world's cultural diversity. These examples merely scratch the surface of her remarkable ethical and humanitarian legacy: a mission seamlessly interwoven with her academic pursuits, profoundly influenced by her compassion and unwavering moral conviction.

She passed away in 1956 at the age of ninety-three in East Lansing, Michigan.

A COMPELLING PROTOTYPE OF GEO-PEDAGOGICAL INNOVATION

Zonia Baber revolutionised the teaching of geography and geology through her different, remarkable approach to education. Central to her methodology was the use of chalk modelling, laboratory experiments, and fieldwork, which she viewed as indispensable tools for fostering a comprehensive understanding of Earth processes. By creating three-dimensional models of rivers, valleys, cliffs, and dunes in classroom settings (Baber, 1901a), she enabled students to grasp geological processes such as erosion, sedimentation, and tectonics in a tangible and intuitive manner (Fig. 3). This multisensory approach extended to activities such as dramatic recreations of human-environment interactions — theatrical performances and other forms of creative expression proved particularly effective not only in this context but also in conveying the related customs and traditions of peoples from various parts of the world — further enriching the educational experience (Baber, 1901a).

Baber recognised laboratory experiments as a vital complement to fieldwork, essential for connecting theoretical knowledge with real-world landscapes and experiences while reinforcing logical thinking and observational skills (Baber, 1901b, 1905). She devised creative setups to replicate natural phenomena on a manageable scale, including for example rainfall simulators (Fig. 4).

Field excursions formed a milestone of Baber's pedagogy. She meticulously planned and led trips to some of the most geologically significant sites in the United States, which provided students with opportunities to directly engage with and comprehend larger-scale geological phenomena. Revisiting locations further deepened their understanding and fostered iterative learning (Baber, 1901c). Despite logistical and financial challenges, Baber argued that fieldwork cultivated critical thinking, intellectual independence, and a holistic appreciation of human-environment dynamics (Baber, 1901c; 1905). Her unconventional approach was celebrated nationwide, with articles from early 20th-century newspapers (The Evening Times, 1902; The Inter Ocean, 1903), documenting her geological excursions and workshops. These accounts often marvelled at the fact that this tireless cultural revolution was spearheaded by a woman: a profoundly unsettling notion for the time. Baber's pedagogy was also strikingly inclusive and forward-looking for its time. She encouraged international correspondence among students, promoting cultural exchange and mutual understanding (Baber & Atwood, 1900; Baber, 1901d, 1901e), while supporting aspiring educators to combine original activities — e.g., map-making, which stimulated both cooperative and constructive competition among students (Baber, 1904) — to effectively communicate foundational geoscience concepts. Moreover, her educational philosophy emphasised the integration of current events and interdisciplinary perspectives into geoscience education (Baber & Atwood, 1900). She encouraged

Fig. 3 - By manipulating plaster, a class replicates a three-dimensional model of what is drawn on the blackboard as they use Zonia Baber's patented desk during her lessons (Baber, 1901a).

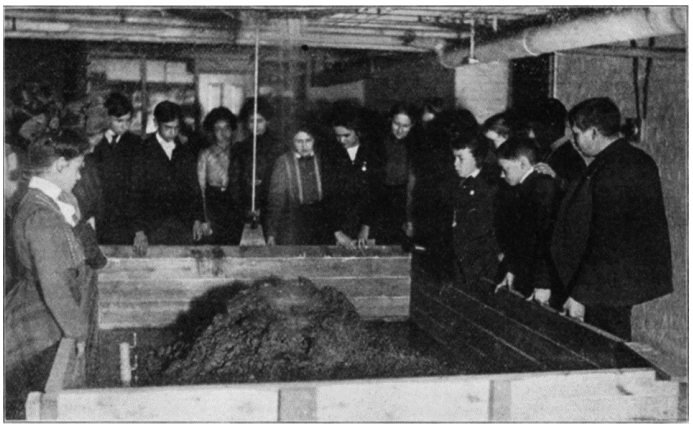

Fig. 4 - A laboratory in the university basement: students are engaged in a hands-on investigation using sand and water as part of their physical geography course (Baber, 1901b).

teachers and students to engage critically with contemporary issues, from geopolitical developments to technological advancements, showcasing geography and geology as dynamic and relevant disciplines (Baber, 1901a, 1901f). For example, she urged educators to help students thoughtfully examine how these topics were portrayed in newspapers and books. In doing so, she sought to extract geosciences from the era's distorted and biased narratives. This approach stimulated independent thinking and equipped students to challenge prejudiced views, promoting a more ethical and informed understanding (Baber, 1901f). If what has been summarised so far may be considered an overview of the most distinctive features of her innovative pedagogy, a more detailed analysis of the available sources confirms its depth and coherence. In that case, some of the papers published by Baber in 1901 (a–f) during her tenure at the University of Chicago, and cited as key references throughout this article, stand as genuine educational modules that highlight the structure of her didactic corpus. These documents offer a unique opportunity to reconstruct the architecture of her lessons and to outline the distinctive patterns of questioning she employed to foster critical thinking and independent inquiry. A close examination reveals a remarkably coherent educational framework, providing precious insights into her vision of geoscience learning. Baber meticulously organised her lessons following a structured progression that consistently privileged observation, investigation, interaction with natural materials, and critical discussion.

As exemplified in the first module (Baber, 1901a), dedicated to the Chicago region and North America, she adopted a field-based learning model, where students directly explored geomorphological features shaped by streams, waves, glaciers, and wind. This observational phase was systematically followed by in-class elaborations, including blackboard drawings, sand models, and lectures delivered by students themselves. Her sequence moved from empirical observation to active representation and finally to public communication, culminating in a participatory environment. Her questioning style frequently invited causal reasoning and hypothetical thinking: questions such as "What would be the effect on the climate of North America if the eastern and western highlands had been reversed in position?" encouraged students to move beyond mere description towards sophisticated environmental insight. The second module (Baber, 1901b), focused on Eurasia, reinforced this structure: starting from continental comparison exercises (e.g., "Is the arrangement of mountains and plains most advantageous for man's occupation?") and leading towards map-making activities and coloured landscape drawings. Her questions prompted comparative analysis and speculative evaluation, nurturing higher-order thinking skills. In the third module (Baber, 1901c) on India, the inquiry-based method became even more pronounced. Students were led to link topography, climate, geology, and socio-economic development through intricate questions such as "How has the Ganges delta plain influenced the development of India?" and "Why are tanks and lakes generally in the archaean?". Here, students were not only absorbing geological and geographical facts but actively constructing an integrated understanding of complex environmental and cultural systems. Module four (Baber, 1901d) addressed the palaeogeography of North America and relied heavily on geological museum exhibits. Students were invited to infer continental evolution through the interpretation of fossil records and ancient coastlines, guided by questions like "What is the evidence that the continent has passed through many changes of climate?" and "Would you predict a larger or smaller future North America?". The emphasis on temporal change and predictive reasoning introduced pupils to a deep-time perspective that was strikingly advanced for elementary and secondary education of the period. The fifth module (Baber, 1901e) proposed an extraordinarily innovative "world's fair" pedagogical project for the elementary school. Here, Baber gave students agency over their learning paths, encouraging them to choose a country, research its geographical and cultural features in depth, and build a full exhibition through models, maps, drawings, dramatic representations, and musical performances. The learning trajectory was deeply experiential and student-driven, with questions designed to trigger independent research, critical selection of information, and aesthetic expression. Finally, in the sixth module (Baber, 1901f) focusing on China, Korea, and Japan, she once again employed a multi-faceted, inquiry-driven approach. Students were guided to investigate physical geography, climate, socio-political structures, and cultural achievements, while questions such as "What constitutes China's greatness?" and "What can the Occident learn from the Orient?" introduced reflective, ethical, and geopolitical dimensions into the geoscience curriculum.

Throughout all six modules, several consistent features emerge: Baber privileged direct interaction with real-world phenomena; structured her lessons to progress from observation to representation to analysis; used questions that demanded comparison, inference, and prediction rather than rote recall; and cultivated autonomous thinking and collaborative learning. Thus, to conclude, Baber's extensive and imaginative use of laboratory experiments, field-based exploration, creative modelling, map-making, and artistic representations revealed a strikingly holistic educational method, one that combined scientific rigour, creative probing, and ethical reflection with remarkable cohesion. By weaving together critical engagement and contextual awareness, she crafted an unprecedented and immersive approach to geoscience education that continues to inspire modern pedagogical practices.

DISCUSSION AND CONCLUSIONS

This article aims to shed light on Zonia Baber's transformative legacy, highlighting her original contributions to active geoscience education. Her dedication to reforming geoscience pedagogy was deeply intertwined with her broader activism, championing the crucial social issues of her time. Beyond her scientific achievements, Baber stood as a feminist and suffragist, a pacifist, an anti-racist, an anti-colonialist, a human rights advocate, and a committed environmentalist. While the full scope of her extraordinary endeavours cannot be fully captured within this context, this work focuses on her educational mission, which served as the foundation for her ethical and social principles. Through her unconventional perspective, she exemplified how geosciences could transcend academia to inspire meaningful societal progress. By encouraging experiential learning, interdisciplinary strategies, and a view of geosciences as a unifying force, she carved out a transformative role in the history of education. Baber's forward-thinking methodology anticipated a broader pedagogical shift that would take decades to gain institutional acceptance. Her educational philosophy aligns with what is now recognised as progressive active pedagogy, or pedagogical activism, an approach rooted in learning through experience and action. Over time, this approach laid the groundwork for what would later evolve into constructivist theories, as articulated by scholars such as Jean Piaget and Jerome Bruner. While John Dewey is often cited as a key figure in this pedagogical shift, some important clarifications are necessary to better understand Zonia Baber's role in relation to the paradigms that were later adopted and developed by the major theorists of modern pedagogy. It is worth noting, firstly, that Baber and Dewey were not operating in distinct pedagogical spheres: they were colleagues at the University of Chicago for a limited period and shared a common intellectual environment for several years. Despite this proximity, and a professional relationship that was not always serene or entirely cordial (Knoll, 2014), Baber developed her radical approach to geoscience education with complete autonomy. Contrary to what many might assume, her educational model was not shaped by Dewey's ideas, which were only systematised in 1938, but rather took early and autonomous form through her direct engagement with classroom practice and her empirical understanding of how students learn. It is plausible, in view of this, that Dewey's later reflections were themselves informed by the innovative work of educators like Baber, whose efforts predated in practice his theoretical synthesis and evolved independently of his framework. Her pedagogical innovations, including the use of scientific apparatus, tactile learning materials, and three-dimensional visualisation aids, empowered students to engage with scientific concepts through direct experience, collaborative engagement, and critical inquiry. Furthermore, the structure and intended use of her patented school desk, for instance, exemplified her belief in tactual and spatial learning as central to the scientific education process. All of this implies that, before John Dewey envisioned the classroom as a democratic, experimental space, and long before he formally articulated the principles of progressive education (Dewey, 1938), Baber had already created inclusive environments rooted in observation, discussion, and experience. Decades before Jean Piaget formulated his theory of cognitive development through environmental interaction (Piaget, 1952), Baber was already designing activities that encouraged her students to manipulate and explore real geological elements and materials to deepen their understanding. Similarly, long before Jerome Bruner introduced the concept of the spiral curriculum (Bruner, 1960) and the principles of discovery learning (Bruner, 1961), she reinforced key concepts through repeated cycles of practical engagement and active exploration. To summarise, these resonances reveal that her methods emerged independently of prevailing doctrine, shaped instead by her intuitive grasp of how students best learn, as driven not by abstract theory but by grounded, empirical practice. What emerges from this retrospective analysis is hence a striking alignment between Baber's pedagogical methods and the core tenets of the constructivist model, an affinity that is far from coincidental. Rather, it underscores the depth of her educational foresight in shaping the foundations of experiential geoscience learning long before such frameworks were formally articulated. Her work thus demonstrates that visionary educators were already advancing transformative practices from within the classroom itself, developing labour-intensive, student-centred strategies to support the deep assimilation of complex concepts. And furthermore, the prescience of her teaching invites a broader recognition of revolutionary women educators, often excluded from theoretical circles, whose contributions have long been eclipsed by the very systems they helped to transform. In this light, Zonia Baber should also be recognised as a foundational, even though unacknowledged, figure in the genealogy of progressive pedagogy.

The biggest obstacle in reconstructing the life and work of Zonia Baber lies in the scarcity of available information: often incomplete, occasionally inaccurate, and regrettably difficult to access. University archives serve as invaluable repositories, safeguarding the pedagogical framework of Baber's holistic teaching methodology. However, a significant gap persists: the inability to fully trace the narrative of her life as a geoscientist, which appears to have been overshadowed by her educational and social mission, as well as her tireless activism. Indeed, what can be pieced together relies heavily on her career as a professor, educator, and campaigner for justice and equality, while her academic contributions as a geologist and geographer remain elusive and fragmentary. This paucity of comprehensive biographical and scholarly records is both a reflection of the historical marginalisation of women in science and a reminder of the systemic barriers faced by feminine trailblazing figures. Apart from the articles on geoscience education authored by Baber herself, subsequent developments or scholarly attention to her work are strikingly absent, as if her contributions, upon the conclusion of her career, were reduced to a fleeting chapter, soon forgotten and left unexplored. Even this oversight mirrors a broader historiographical trend of marginalising figures — again, nearly always women — whose work crosses disciplines and challenges entrenched cultural barriers. Addressing this gap requires not only a re-examination of her educational and social legacy, but also a determined effort to position her within the larger narrative of geosciences history as a transformative, yet still underappreciated, pioneer.

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