SCIENCE & NATURAL HISTORY MUSEUMS FOR CRITICAL SCIENTIFIC LITERACY AND SOCIAL CHANGE: A CRITICAL PERSPECTIVE ON WHERE WE ARE NOW AND WAYS FORWARD

L. Diogo[1], F. Alves[1,2], D. Vidal[1,2], J. Manso Sayão[3]

[1]Centre for Functional Ecology—Science for People & the Planet, Associate Laboratory TERRA, Department of Life Sciences, University of Coimbra (PORTUGAL)
[2]Department of Social Sciences and Management, Portuguese Open University (PORTUGAL)
[3]Federal University of Rio de Janeiro - National Museum (BRAZIL)

Abstract

Science & Natural History Museums (SNHMs) face unprecedented pressure to address escalating socioecological crises while combating misinformation and weakening public trust in science. Despite growing institutional acknowledgement of socioecological responsibility, most SNHMs remain constrained by technocratic paradigms and colonial legacies that limit transformative potential. Through a qualitative critical literature review spanning two decades of museum studies, science education, and critical pedagogy, we identify key barriers preventing SNHMs from embracing critical museology and outline pathways toward transformative practice.

Our findings demonstrate that reimagining SNHMs requires understanding their present scientific authority, as historically has been, to naturalise social hierarchies and justify extractivist relations with the natural world. The pathway to achieve this encompasses integrating critical scientific literacy (CSL) frameworks that address political, ethical, and emotional dimensions of knowledge. This transformation demands: (1) explicitly recognizing power dynamics within educational processes; (2) advancing genuine shared authority with communities; (3) fostering collaborative, civically engaged learning; and (4) building stronger research-education-policy alliances. SNHMs must transcend custodial roles to become agents of socioecological justice, accepting that complexity and resistance are inherent to meaningful transformative education.

Keywords: Science & Natural History Museums, Critical scientific literacy, Critical museology, Transformative learning, Environmental & Sustainability education, Socio-ecological justice, Critical pedagogy, Non-formal education.

1 INTRODUCTION

Engaging in a critical conversation about the responsibility, role, and educational potential of Science and Natural History Museums (SNHMs) to foster social change requires situating the discussion within the broader context of human inaction in a world facing a deepening socio-ecological crisis. Recent global assessments and scholarly literature concur that the current planetary condition is shaped by what can be described as a *triple action-crisis*: a sustainability science crisis as a result of crises of information and education, which converges in an axiological crisis. The result is a widening gap between scientific knowledge and the collective capacity — or willingness — to act upon it, despite unprecedented technological development and communication possibilities. SNHMs' historical legacies, epistemic authority, and public visibility position them as powerful actors in shaping how societies understand and respond to the challenges of the Anthropocene. Yet, this potential remains constrained by institutional inertia, neoliberal pressures, epistemic tensions, and political risks that limit their capacity to embrace transformative practices inspired in critical scientific literacies (CSL).

To address these issues, the paper revisits five guiding research questions: (1) *Which societal and educational changes are most needed in the current global crisis context?* (2) *How has the concept of scientific literacy (SL) evolved to address present societal challenges and become a necessary goal of science education? (3) Which new roles must SNHMs assume today in promoting public CSL? (4) How critical museology aligns with CSL shaping SNHMs futures? (5) Which key limits constrain the full embrace of critical museology practices for social change?*

The paper first contextualises the historical heritage of museums within contemporary demands for global action and argues that critical social and pedagogical theory offers the most adequate analytical

https://doi.org/10.21125/inted.2026.1088
ISBN: 978-84-09-82385-7

lens. It then revisits the transformation of museum education through critical museology, identifying the limits and constraints that continue to hinder institutional change. Finally, it demonstrates how embracing institutional transformation requires SNHMs to adopt the shift from SL to CSL if they ought to foster transformative educational environments.

2 METHODOLOGY

A qualitative narrative literature review was conducted across interdisciplinary sources spanning the past two decades, focusing on critical pedagogy, scientific literacy (SL), environmental education, and museum education. The review covered conceptual frameworks, key debates, and international normative instruments, drawing on specialised journals in museum studies, science education, and sustainability. This was complemented by interpretative discourse analysis of selected review papers and policy documents, with particular attention to scientific literacy and transformative education.

3 SOCIETAL CHALLENGES DEMAND NEW ROLES FOR EDUCATION

3.1 Inaction in a world in crisis

Over the past five decades, global institutions and scientific communities have repeatedly warned that the planetary crisis results from deeply dysfunctional socio-ecological systems and the escalating threats they have been facing [1],[2]. The growing destabilisation of Earth system is recognised as increasingly interdependent and unequivocally driven by human activity. A recent shift in the international conceptualisation of sustainability, by the European Commission on the Monitoring learning for sustainability: developing a cross EU approach report, now defines it as “prioritising the needs of all life forms and of the planet by ensuring that human activity does not exceed planetary boundaries. It considers environmental, economic, social, and political systems as interconnected systems, and involves the transformation of structures, agency, values, and attitudes”. Yet, and despite overwhelming evidence, global inaction persists. The Intergovernmental Panel on Climate Change (IPCC), once again, warned that “at the current rate, warming will reach 1.5°C by around 2040 and possibly earlier. Taken together, current national policies to reduce greenhouse gas emissions put the world on a pathway to warming of at least 3°C by 2100 […]” as stated by United Nations Environment Programme in Making Peace with Nature A scientific blueprint to tackle the climate, biodiversity and pollution emergencies (UNEP, 2021). Changing course requires urgent and radical transformations — decarbonisation, ecological restoration, food security, and social renewal — yet, these pathways face significant political and governance obstacles [1],[2].

Paradoxically, the present moment reveals a widening gap between human knowledge and the decision to act accordingly, despite living in an era of unprecedented technological development and limitless communication possibilities. This paradox is central to understanding why educational and cultural institutions, including museums, must rethink their roles in fostering public engagement, critical understanding, and collective responsibility.

3.2 The triple action-crisis: sustainability science in crisis as a result of information, education, and axiological crises

Explaining the persistent knowledge – action gap requires acknowledging what can be described as a *triple action-crisis*: a sustainability science crisis emerging from intertwined crises of information, education, and values. The crisis of information integrity is identified by the assessments from the International Panel on the Information Environment (IPIE), highlighting how contemporary media and communication systems exacerbate the climate crisis: powerful actors intentionally disseminate “inaccurate or misleading narratives about anthropogenic climate change”, eroding public trust in science and undermining policy coordination. This produces a feedback loop between scientific denialism, political inaction, and public confusion.

Climate change discourse, for example, has shifted from outright denialism to a more insidious scepticism that recognises climate change as a fact while undermining “scientific evidence of the human causes and (its) social consequences […] (and) promotes doubt about the feasibility and cost effectiveness of climate policies”, states IPIE in the Facts Fakes and Climate Science. Efforts to delay action are increasingly waged through the information environment, where policymakers themselves become targets of misinformation. Inaction also occurs when leaders decide to ignore, many times over, the scientists' warnings about the catastrophic socio-ecological results of the “socioeconomic dynamics of recent decades” [2], as with *The Club of Rome,* in 1972 initially and again in 2022, just to give an

example. And even when massive support from a variety of international and independent scientific commissions presents overwhelming evidence, they simply “divert attention to other more urgent phenomena. Among all, the most important is war and the associated insecurity” [2], let alone, we must add today, the systematic demolition of Human Rights, International Law and the Institutions standing up for them. Such man-made conditions lead us all to growing global insecurity caused, not only by the direct devastating impacts on humans and the entire biosphere (and, eminently, their annihilation), but also by demanding our attention and profound concerns away from the ecological crisis, even more aggravated by today´s global military scenario [2].

As Nobel Peace Prize laureate Maria Ressa, in her book *How to Stand Up Against a Dictator: The Fight for Our Future* (2022) warns, journalists are at war, members of the press are murdered, while perpetrators maintain impunity. The author explicitly denounces a new form of warfare unfolding in which government officials increasingly deploy “keyboard armies” who assail the credibility of journalists in reporting facts, news, and information. Thus, the problem of public and political engagement for social change is no longer “just about carbon — it is about credibility” [IPIE, 2025, Facts Fakes and Climate Science]. Countering these conditions, as the scientific community recommends, should be done through the creation of counter-publics, “alliances of citizens, local communities, and civil society organisations — to counterbalance the alliances built by the corporations, policy lobbies, and think tanks” acknowledging that “science and media literacy represent a long-term strategy that empowers citizens and publics to respond to the crisis of information integrity” [IPIE, 2025, Facts Fakes and Climate Science].

3.3 Implications for educational institutions

As scholars have long argued, doing so demands a profound transformation of education toward ethical and ecosophical planetary frameworks, or humanity will remain unable to confront the civilisational collapse already underway [2]. Instead, inaction in questioning and changing the educational paradigm has brought us up today with “education experiencing compounded crises” of equity and relevance — as reinforced by the UNESCO’s Report on the 2022 Transforming Education Summit, being exacerbated by the inherent complexity of sustainability, but also by the power of counter-narratives designed to block civic and political action, as stated by the IPIE. In fact, UNESCO’s recent report, *Reimagining Our Futures Together: A New Social Contract for Education,* likewise calls for recognising the unfolding global educational crisis and rebuilding education upon equity, sustainability, and collective responsibility. The report argues that education must “unite us around collective endeavours and provide the knowledge, science, and innovation needed to shape sustainable futures for all — anchored in social, economic, and environmental justice”. As current systems remain “no longer fit for purpose”, it urges us to revisit the very purposes of education as humanity faces an existential dilemma between pursuing an unsustainable path or radically changing course — a *breakdown* or *breakthrough*” dilemma, supports the UN’s report Transforming Education Summit. Many voices agree that educational institutions have largely failed to respond adequately to the ecological crisis, and that, in many cases, they have been complicit in reproducing anthropocentric, competitive, and nationalistic world-views, a perspective supported by UNEP in the Making Peace with Nature report and others works [2],[3]. Hence, alternative epistemic, axiological, and existential views, as much as critical thinking are fundamental for cultivating planetary consciousness, ecological humility, and cooperative ethics. UNESCO explicitly states that education for sustainable futures must be anchored in justice — social, economic, and environmental — and must address past injustices while preparing learners for uncertain futures. Moreover, it states that current failures are compounded by chronic underinvestment, weak governance, and the inability of education systems to address environmental justice, social cohesion, and the skills needed for uncertain futures.

This context sets the stage for understanding why museums — particularly SNHMs — must rethink their roles, responsibilities, and educational missions. Assuming efforts for social transformation means SNHMs must understand the reasons behind human inaction and recognise their own specific role within the broader educational landscape. The persistence of traditional practices is part of the problem. Still, their historical legacies, epistemic authority, and public visibility are what position them as critical actors in addressing the triple action-crisis through science education. Finally, meaningful transformation in such institutions, requires robust alliances between researchers, educators, policymakers, and communities. SNHMs cannot foster institutional transformation in isolation. They need, according to UNESCO, stronger alliances between research, education, and public policy.

4 CRITICAL MUSEOLOGY AND CRITICAL SCIENTIFIC LITERACY: A NECESSARY CONVERGENCE IN SCIENCE & NATURAL HISTORY MUSEUMS

SNHMs carry institutional histories deeply rooted in colonial, extractivist, and positivist scientific traditions. These legacies shape their collections, taxonomies, exhibition practices, and epistemic authority. As a result, attempts to introduce critical, justice-oriented approaches often collide with entrenched institutional cultures that prioritise neutrality, objectivity, and the preservation of traditional scientific narratives [9],[10],[11]. Critical museology offers a powerful framework to address these tensions inviting museums to confront their complicity in producing and legitimising dominant narratives, and embrace practices that foreground plurality, dissent, and the co-construction of knowledge. It challenges the dualist, hierarchical, and exclusionary foundations of traditional museology and calls for museums to become agents of social and environmental justice. Emergent international museological perspectives demonstrate an awareness of the entanglement of social and environmental justice, and some individual museums are engaged in "progressive and creative practices that critique and transgress" dualistic visions of human – nature relations, to engage in crucial social-ecological issues" [3]. However, this shift is far from straightforward. As some note, "museum work surfaces a core tension in that trends towards a relational and emancipatory practice are paradoxically embedded within neoliberal ideology" [3]. Neoliberalism perpetuates the human – nature dualism inherited from colonialism and constrains the development of progressive, justice-oriented museum practices [3].

4.1 Science & Natural History Museum's historical legacies, epistemic tensions and contemporary pressures

Transforming Science and Natural History Museums (SNHMs) into institutions capable of fostering social change is both a necessary and a profound challenge. Education emerges as a critical arena for such work. Constrained by economic pressures, which reinforce depoliticised and consumption-oriented models of public engagement [3],[6],[11] these institutions remain hostage of legacies deeply embedded in their collections, narratives, and institutional cultures [6],[11]. This historical inheritance carries profound implications. SNHMs have long contributed to the naturalisation of an idea of science that has, in fact, led to the advancement of certain civilisations at the expense of others, their knowledge systems, territories, and freedoms. By failing to confront their own epistemic and political histories, SNHMs may inadvertently foster ecological alienation — promoting a dogmatic belief in a neutral, uncontaminated scientific-technological body capable of saving humanity from the very crises it helped create [6],[9]. This reinforces the illusion that science alone, detached from ethics, politics, and social responsibility, can guide us toward sustainable futures. This inertia is even more reinforced by the symbolic power of museums as custodians of "universal" knowledge, where questioning the 'neutrality' of science or exposing colonial histories can be perceived as threatening to the institution's identity [8].

Moreover, the struggle to reconcile their historical roles with the demands of a rapidly changing world [10],[11] is facing another major barrier to transformation that can be traced in neoliberal pressures leading to the commodification of museum practices [3]. In fact, the neoliberal restructuring of cultural institutions, over recent decades, has increasingly pressured museums to adopt market-driven logics that equate innovation with entertainment, success with visitor numbers, and public engagement with consumer satisfaction. This shift has led to the prioritisation of spectacle over critical inquiry; depoliticisation of content to avoid controversy; reliance on corporate sponsorships that may conflict with justice-oriented missions, and precarious labour conditions that limit expertise and staff capacity for innovation. As Jeffery notes, emancipatory and relational museum practices are "paradoxically embedded within neoliberal ideology, which perpetuates the human-nature dualism inherited from colonialism and constrains the development of progressive social-ecological forms of museum practice" [3]. Furthermore, epistemic tensions within science itself arise: traditional science literacy models reinforce the idea of science as neutral, apolitical, and universally valid, while the social nature of knowledge (Vygotsky) and the need for ethical and political reflexivity — as museums increasingly operate in politically polarised societies — addressing climate justice, colonial histories, or socio-scientific controversial issues can provoke public or governmental backlash. As an example, right-wing movements have targeted critical pedagogies, describing them as "promoting resentment" or ideological indoctrination. This creates a climate of fear that discourages institutions from adopting transformative approaches [9]. At the same time, the rise of misinformation, denialism, and attacks on scientific credibility intensifies the risks associated with taking public positions on socio-scientific issues (SSI). In fact, the International Panel on the Information Environment warns that the problem is no longer "just about carbon — it is about credibility". For SNHMs, these tensions manifest in the reluctance to address the political dimensions of climate change, biodiversity loss, or environmental justice; fear of being

perceived as partisan; difficulty integrating indigenous, local, or alternative knowledge systems, and challenges in presenting uncertainty, dissent, and controversy as legitimate components of science [10],[11]. Bazzul (2020) lays out that discussing the nature of science (NOS) to foster social justice "makes sense because science has already come to play a large role in both the emergence and mitigation of these phenomena" [13]. Hence, mmuseums' that cling to neutrality risk reinforcing ecological alienation and undermining public capacity for democratic engagement [8].

4.2 Critical Scientific Literacy as a framework for transformation

The assumption that scientific knowledge alone can guide societies toward sustainable futures has proven to be wrong. Therefore, addressing the planetary crisis requires a profound rethinking on how science is taught, communicated, and socially understood. As Guerrero & Sjöström (2024) argue, future research in environmental and science education must foster an understanding of "how to adopt new practices aligned with critical literacy approaches, which implies recognising the political, ethical, emotional, cultural and economic dimensions intertwined with environmental and science education [...]" [5]. This shift reflects a broader recognition that science education cannot remain neutral in face of Earth system destabilisation, democratic erosion, and widening social inequalities. Political dissent is, therefore, not a threat to science education — it is a necessary condition for democratic and emancipatory engagement. Intense debates regarding the nature of science are necessary, now, to political engagement essential to combat climate change, to question extractivist economic systems, and to fight against structural inequities. Ultimately, meaningful educational dialogue depends on unmasking power dynamics that are often presented as neutral or disconnected from socio-environmental damage [7],[13].

The evolution of scientific literacy (SL) is often described through the framework of Vision I, Vision II, and Vision III [5],[7],[12]. Vision I represent the "cold end" of the spectrum, focusing on canonical scientific knowledge and disciplinary concepts. Vision II expands this by emphasising the societal relevance of science, integrating NOS and Science-Technology-Society-Environment (STSE) perspectives. Yet, as several scholars argue, even Vision II remains insufficient for addressing the depth of today's socio-ecological challenges [5],[7],[12]. Vision III — also referred to as *critical scientific literacy* — marks a decisive shift. It integrates philosophical reflection, ethical reasoning, and socio-political action into science education. As Sjöström (2025) explains, Vision III aims for *both* students and teachers to develop "a holistic, ethical and political attitude regarding STSE relationships" and to engage with science through eco-reflexive *Bildung* (the classical German pedagogical concept for "integral formation"), which foregrounds moral, philosophical, existential, and political dimensions of learning. This approach recognises that scientific understanding is always shaped by ideological, ethical, and experiential factors. Teaching SSI, therefore, requires navigating strong emotions, shifting teacher roles, and complex assessment practices [12]. In this sense, Vision III is not merely an extension of previous models; it represents a paradigmatic transformation. It positions science education as a space for critical inquiry, democratic participation, and socio-ecological responsibility [12].

For SNHMs, the convergence between critical museology and CSL is not optional — it is foundational [10]. Museums that continue to rely on traditional, depoliticised models of science communication risk reinforcing ecological alienation and perpetuating the very narratives that contributed to the crisis. By contrast, integrating CSL allows SNHMs to: foreground the ethical and political dimensions of scientific knowledge [10]; challenge colonial and extractivist legacies; support public engagement with uncertainty, dissent, and complexity; foster civic participation and socio-ecological responsibility, and contribute to the formation of counter publics capable of resisting misinformation.

This convergence positions SNHMs as transformative educational institutions capable of addressing the triple action-crisis and contributing to planetary justice. Its impact can be found, for instance, when in curatorial exhibition planning, decision-makers open the dialogue about thematic choices also to the community, scrutinising their most needed interests about critical, situated and, eventually, controversial SSI.

4.3 Science & Natural History Museums as spaces for socio-political engagement and transformative learning environments

Science and Natural History Museums (SNHMs) are increasingly redefining themselves as "agents for change and transformation in society [6],[11]. Many are committed to social justice, equity, and community engagement, which establishes them as significant cultural and educational entities" [6]. SNHMs serve communities "as hubs for scientific research" and provide "a uniquely authentic environment that promotes public engagement in scientific inquiry and exploration" [6]. Their authority,

collections, and public visibility position them as vital spaces for addressing broader societal issues, as structural inequities, colonial legacies, and biodiversity loss.

Scholars also increasingly highlight the intersections between the nature of science (NOS) and social justice (SJ), emphasising that scientific knowledge is not produced in a vacuum but is shaped by historical, cultural, and political forces. Engaging critically with NOS, therefore, requires confronting how scientific institutions — including museums — have contributed to exclusionary practices and inequitable knowledge production [6],[7].

Political dissent becomes an essential dimension of NOS discussions, as "vigorous debates about the nature of science become a vital part of political struggles to combat climate change, environmental racisms, destructive resource extraction, extinctions and widening social inequality" [13]. This positions SNHMs not as neutral spots for transmission of knowledge but as active participants in democratic and socio-ecological struggles. In short, engaging in critical educational conversations requires exposing the narratives of power disguised as neutrality or innocence [4]. Neutrality, as much as indoctrination, is neither possible nor desirable in education. As critical pedagogy reminds us, education that situates problems in their historical contexts enables learners to understand how the status quo emerged and how it might be transformed.

In our view, it is very important also moving beyond the boundaries of informal learning — often associated with entertainment, passive consumption, and depoliticised engagement — toward non-formal education, which is intentional, structured, and explicitly oriented toward a defined goal, and as such, allowing the commitment to include civic participation and social transformation in educational museums planning. Hence, museums that embrace this approach should intentionally foster the competencies needed for democratic participation in sustainability decision-making. Using their unique position to support this transition, their collections and exhibitions can serve as catalysts for: critical reflection on the historical and political dimensions of science (NOS); engagement with socio-scientific issues (SSI); exploration of uncertainty, dissent, and ethical dilemmas; emotional and affective learning, and community-based inquiry and activism.

5 CONCLUSIONS

The contemporary world is marked by growing global insecurity, driven not only by direct socio-ecological impacts but also by dynamics that divert public attention away from the ecological crisis. In this context, Science and Natural History Museums (SNHMs) stand at a critical crossroads. Faced with accelerating socio-ecological crises, deepening inequalities, and a persistent gap between scientific knowledge and social action, these institutions can no longer rely on traditional, depoliticised models of science communication. Evidence suggests that many museums remain anchored in conventional roles and epistemologies, limiting their capacity to respond meaningfully to ongoing social and environmental transformations.

SNHMs carry historical legacies rooted in colonial, extractivist, and exclusionary scientific world-views that have privileged certain cultures and forms of knowledge while marginalising others. This legacy entails a heightened responsibility at a moment when socio-ecological transformation and the questioning of power structures have become indispensable, and when science education emerges as a critical arena for such engagement. Responding to this responsibility requires promoting forms of scientific and environmental literacy that explicitly integrate ethical, political, emotional, and relational dimensions.

The shift from traditional scientific literacy towards Critical Scientific Literacy (CSL) provides a robust conceptual foundation for this transformation. By embracing transdisciplinary, political, and justice-oriented perspectives, CSL foregrounds the need for citizens to critically engage with socio-scientific issues (SSI) and the structures that shape them. Reimagining the role of SNHMs therefore demands more than incremental change: it requires confronting colonial histories embedded in collections, resisting neoliberal logics that equate innovation with entertainment, and embracing the complexity, uncertainty, and dissensus inherent to socio-scientific debates. Strengthening alliances between research, education, and public policy is essential, as museums cannot foster planetary justice in isolation. Beyond being custodians of the past, SNHMs are challenged — and uniquely positioned — to become co-creators of more just and sustainable futures.

ACKNOWLEDGEMENTS

The authors acknowledge the support of the R&D Unit Centre for Functional Ecology—Science for People & the Planet (CFE), with reference UIDB/04004/2025, financed by FCT/MCTES through national

funds (PIDDAC) with an extension at the University Aberta, the Associate Laboratory TERRA, with reference LA/P/0092/2020. Lídia Diogo was supported by the Portuguese Foundation for Science and Technology (FCT) through a PhD scholarship (grant number 2024.18435.PRT).

REFERENCES

[1] Rödel J, Frisch A, Damjanovic D. The scientists' responsibility in communicating the sustainability crisis. J Mater Sci. 2023 Oct;58(40):15577–87.

[2] Galán AS, Pérez LT. Scientists Warning that Nationalism or Militarism Ideologies Block the Urgently Needed Planetary Consciousness. 2024;7

[3] Jeffery TC. Critical Realist Philosophy and the Possibility of an Eco-decolonial Museology. Museum & Society. 2021 Mar 8;48–70.

[4] Hart P. Reflections on Reviewing Educational Research: (Re)searching for value in environmental education. Environmental Education Research. 2003 May;9(2):241–56.

[5] Guerrero G, Sjöström J. Critical scientific and environmental literacies: a systematic and critical review. Studies in Science Education. 2025 Jan 2;61(1):41–87.

[6] Pshenichny-Mamo A, Lodge W, Tsybulsky D. The Intersection Between Social-Institutional Aspects of Nature of Science and Social Justice in Natural History Museum Exhibitions. Sci & Educ [Internet]. Available from: https://link.springer.com/10.1007/s11191-025-00708-2

[7] Valladares L. Scientific Literacy and Social Transformation: Critical Perspectives About Science Participation and Emancipation. Sci & Educ. 2021 June;30(3):557–87.

[8] Hine A, Medvecky F. Unfinished Science in Museums: a push for critical science literacy. JCOM-J Sci Commun. 2015;14(2): A04.

[9] Morales-Doyle D. Putting science education in its place: the science question in social justice education. Cult Stud of Sci Educ. 2023 Mar;18(1).

[10] Pedretti E, Iannini AMN. Towards fourth-generation science museums: changing goals, changing roles. Cult Mus. 2023;(41):151–86.

[11] Pedretti E, Iannini AMN. Controversy in Science Museums: Re-imagining Exhibition Spaces and Practice [Internet]. 1st edn. Routledge; 2020 [cited 2026 Jan 9]. Available from: https://www.taylorfrancis.com/books/9780429017766

[12] Sjöström J. *Vision III of scientific literacy and science education: an alternative vision for science education emphasising the ethico-socio-political and relational-existential.* Studies in Science Education. 2025 July 3;61(2):239–74.

[13] Bazzul J. Political Entanglement and the Changing Nature of Science. In: Yacoubian HA, Hansson L, editors. Nature of Science for Social Justice. Cham: Springer; 2020. p. 79-95. doi: 10.1007/978-3-030-47260-3_5