Multidisciplinary and Intergenerational Collaboration: A Multi-Perspective Study on the Role of Youth in the Raw Materials Environment

Multidisciplinary and Intergenerational Collaboration: A Multi-Perspective Study on the Role of Youth in the Raw Materials Environment

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In today's rapidly evolving world, different forms of innovation play a pivotal role in shaping the future of the current youth and achieving intergenerational justice in the energy transition. This paper seeks to assess the state of intergenerational collaboration and recommendations on how to better utilise the potential of youth, focusing on their role in the raw materials sector. It employs existing literature, an expert workshop at the International Round Table on Materials Criticality 2024, and a disseminated survey to investigate intergenerational collaboration within Europe's raw materials sector and beyond, with insights on governance, business, academia, and civil society pillars. Discussing the barriers to youth inclusion in the raw materials sector, this paper seeks to inspire more research on this seemingly underexplored area. Key findings are thoroughly assessed and discussed, resulting in meaningful recommendations to bridge generational gaps within the sector and ensure an inclusive transition.

1. Introduction

The number of young people on earth has never been higher than it is today. Over 50% of the global population is under 30 years old, with the majority residing in the Global South [1]. This trend is expected to continue well into the future. Unprecedented connectivity and interdependence, facilitated by globalisation, has enabled youth to actively contribute innovative solutions, drive progress, and advocate for political change in their communities. However, substantial disparities still exist when it comes to youth inclusion in governance, business, academia, and civil society. Economic, social, and political factors, both for and against youth inclusion, exist. Nevertheless, the current decision-making generations bear the moral obligation to incorporate principles of intergenerational justice. This implies that present generations hold certain responsibilities toward future generations, such as ensuring available natural resources are used in a manner that does not jeopardise the sustainable functioning of future generations [2].

Intergenerational collaboration is typically defined as a coordinated effort between two or more generations towards a shared objective [3]. The time span of a generation typically ranges between 20 and 30 years [4-6], with about 2-3 generations coexisting at once. Interdisciplinarity refers to an approach that combines different disciplines, concepts, or methods to achieve a shared aim [7]. Academic alumni from geosciences can

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likely attest that geosciences have always embraced intergenerational and interdisciplinary aspects. Research often requires converging expertise from fields such as chemistry, physics, biology, mathematics, computer science, and engineering; moreover, knowledge transfer between generations is the norm in academia. However, in a swiftly evolving world, it is necessary to question whether the current degree of intergenerational and interdisciplinary collaboration within geosciences, inside and outside academia, adequately addresses the global challenges that future generations will face. Examination of the current state-of-the-art of intergenerational collaboration within the European raw materials environment, especially in the four key societal pillars of Governance, Business, Academia, and Civil Society, was conducted to explore existing practices and insights regarding intergenerational collaboration in the European raw materials sector. The literature review concentrated on academic publications, policy documents, and reports from relevant organisations mentioned below.

1.1. Governance

Governance refers to the systems and processes through which societies make decisions, allocate resources, and enforce rules and regulations. It includes governmental bodies, public institutions, and policies that impact society's functioning. An understanding of the state of governance offers insights into the political, legal, and regulatory frameworks that guide economic activities, social welfare, and environmental policies [8]. As global challenges progress, there is an increasing attention within International Organisations (IOs) to recognise and incorporate the voices, perspectives, and talents of young people as critical stakeholders in intergenerational justice. Intergenerational collaboration and youth inclusion are mentioned in numerous strategies and papers by leading IOs such as the United Nations (UN) [9], World Health Organisation (WHO) [10], UN Educational, Scientific, and UN Human Rights Office of the High Commissioner (OHCHR) [11]. These organisations have emphasised the growing importance of youth inclusion within the framework of international governance and organisational structures. However, meaningful inclusion requires more than just acknowledgement statements. Inclusive, accessible, and, to some degree, influential participatory mechanisms such as youth councils, policy-making forums, and advisory committees are vital for a sustainable and inclusive global development. These mechanisms can be leveraged through the employment of junior staff or increasing democratic youth representation in parliaments, effectively bringing the youth to the decision-making table.

1.2. Business

Businesses play a crucial role in shaping the economy, creating employment opportunities, and producing goods, processes, and services essential for societal development. They contribute to employment, wealth creation, innovation, and technological advancement [12]. Steep hierarchies can hinder collaboration and motivation, particularly when the social hierarchies between younger and older generations are translated into the workspace, where juniors may feel undervalued and hesitant to contribute ideas, leading to a stifled and less dynamic work environment [13]. Numerous businesses incorporate youth participation to cultivate an innovative culture, empowering young leaders through fellowship programs and actively soliciting their ideas to stimulate the production of forward-thinking and disruptive solutions [14]. Youth entrepreneurship also fosters intergenerational collaboration in businesses by bringing fresh perspectives, technological proficiency, and innovation. This collaboration allows for the exchange of knowledge and experiences between younger and older entrepreneurs, resulting in adaptability, resilience, and enhanced networking opportunities for business growth. However, significant disparities in youth inclusion and entrepreneurship rates persist, varying by geographical location, industry, and corporate culture. An OECD study indicates that nearly 40% of people express an interest in entrepreneurship, yet only 5% of EU youth and 9% of OECD youth work in entrepreneurial settings [15]. Comparatively, other regions like Indonesia and the USA exhibit higher youth entrepreneurship rates, with around 20% young entrepreneurs [16]. The European Union (EU) has undertaken several initiatives to boost innovation and entrepreneurship in the raw materials sector for sustainable economic growth. The European Institute of Innovation and Technology (EIT) on RawMaterials (EIT RawMaterials) has set up specific programs for youth, such as innovation and business creation programs to boost entrepreneurship and innovation amongst young raw materials experts. Simultaneously, startup accelerators offer resources to early-stage ventures, including access to funding and market opportunities [17]. The European Raw Materials Alliance (ERMA) also plays a crucial role in ensuring sustainable access to raw materials by fostering collaboration between industry stakeholders, academic institutions, and governmental bodies. These initiatives aim to bridge the gap between academic research and commercialisation, diversify supply chains, and advance sustainable development within the raw materials sector [18].

1.3. Research and Academia

The state of youth inclusion and intergenerational collaboration in academia and research is naturally linked to the educational journey that youth undergo in educational systems at schools and universities. There, they can shape research, include their perspectives, and collaborate across generational lines with older, often academically more advanced generations. However, currently, there is little empirical evidence on the state of intergenerational collaboration in different industries across various cultural, geographical, economic, social, and political contexts. Although the EIT RawMaterials, an EU institutional and instrumental body, is helping boost education amongst undergraduate students through EIT-label (and funded) research projects, MSc and PhD degrees within the raw materials field, the EU's mining and minerals industry faces a shortage of young graduates and skilled professionals [19]. Studies show a shift in education from developed to developing countries, with China producing a significant number of academic graduates, while regions of the Global North like Australia, North America, and Europe, have fewer academic graduates compared to industry demand [20]. There is also a trend of engineers leaving the minerals engineering discipline for other professions, particularly in Europe. Young people in Europe are showing a growing lack of interest in pursuing careers within the raw materials industry, primarily due to concerns regarding its reputation and working conditions. Data on the development of enrolled students in raw materials related programs like mining and raw materials processing is estimated to

account for only around 1% of the global study programs [21].

1.4. Civil Society

Civil society organisations (CSOs) play a vital role in shaping public discourse, mobilising collective action, and driving change focused on current and future societal needs rather than economic and political gains. Unlike governance, academic, or business entities, CSOs work within more flexible structures, prioritising underrepresented voices and often serving as a democratic corrective to those in power [22]. Noteworthy examples include youth ambassadors for IOs, such as climate champions for the annual Conference of Parties (COPs), and youth councils participating in board meetings. For marginalised youth groups, such as indigenous or LGBTQI+ youth, who often encounter systemic barriers to education, business opportunities, and political participation due to colonial legacies and societal marginalisation, involvement in civil society activism can provide a crucial platform for their voices to be heard [23]. In Europe, mining (minerals and metals) and raw materials processing have deep historical roots, shaping not only economic development but also societal and environmental landscapes. However, these activities have often been accompanied by significant social and environmental impacts, leading to the emergence of divergent perspectives within civil society. Civil society organisations in Europe related to raw materials and mining encompass a wide range of groups, including environmental non-governmental organisations (NGOs), community-based organisations, indigenous rights advocates, labour unions, and social justice movements. These organisations play crucial roles in advocating for sustainable practices, environmental protection, social justice, and community empowerment of group minorities. Environmental NGOs like the European Environmental Bureau (EEB) campaign against destructive mining practices and advocate for more responsive resource management [24]. Community-based organisations, such as the Save Rosia Montana campaign in Romania, defend local communities' rights and environmental justice [25]. Indigenous rights advocates like the Sami Council work to protect indigenous territories from intensive mineral extraction and promote sustainable alternatives [26].

Governance, business, research & academia, and civil society pillars notably affect the dynamics of intergenerational collaboration. As global challenges continue to advance, it is imperative to utilise the resources that youth bring to the table. Hence, through this study, we aim to stimulate discussion and inspire further research that can offer valuable insights into intergenerational collaboration in the European raw materials environment, which has been a considerably underexplored yet key area for sustainable development. The current landscape of youth inclusion and stakeholder perspectives from both younger and older generations within the geosciences domain was studied. Consequently, in-depth discussions on the underexplored potential for enhancing youth inclusion, intergenerational collaboration, and ultimately, intergenerational justice within the field of geosciences, especially in the raw materials sector was further assessed through workshop and survey findings with raw materials experts of different ages and generations.

2. Materials and Methods

This chapter outlines the materials and methods used in researching intergenerational collaboration within the European raw materials environment, with a particular focus on four societal pillars: governance, business, academia, and civil society. The analysis delved into the rationale behind involving youth and their role for intergenerational justice, examined current practices, and identified barriers impeding youth participation.

For the literature review, several libraries and search platforms were utilised, including ScienceDirect, Google Scholar and ResearchGate. Additionally, a general web research was conducted using Google to gather a broad range of sources. The types of sources included in our review were peer-reviewed journal articles, books and theses, conference papers from international institutions, and relevant websites.

Subsequent to the literature review provided in the Introduction section, a workshop was organised with young experts from diverse societal pillars pertinent to the raw materials sector [Appendix A]. The workshop aimed to explore the challenges faced by young professionals and to identify the most prominent barriers, and drivers to their involvement in governance, business, academia, and civil society in the raw materials sector, and further discuss them with the workshop participants. Held on February 21, 2024, at the Politecnico di Torino (Italy), within the International Roundtable on Materials Criticality 2024 (IRTC24), the workshop had 13 participants, including the speakers. Building on insights from the workshop, a simplified Google Forms survey [Appendix B] was developed to validate findings and gather more inputs from individuals of all ages and backgrounds within the raw materials sector.

The survey structure consisted of a personal details section with data collection about birth year, city and country of residence, main professional occupation, societal pillar and field of expertise, followed by a gaps and barriers section with 1 yes/no question, 1 multiple-choice question, and 4 open-ended questions [Appendix C and D]. The full questions of the survey can be found in the Results section. Names and emails were facultative and were not used for this study. The survey sought to explore different perspectives on intergenerational collaboration and identify additional barriers and opportunities for improvement. The survey was distributed among IRTC24 conference participants and shared with the wider network to encompass a diverse range of stakeholders and was closed after 9 consecutive days with 45 responses to mandatory answers and slightly less to facultative answers (average of 30 responses). Data collected from the literature review, workshop, and survey were then analysed to identify recurring themes, patterns, and insights. Qualitative data from workshop discussions and survey responses were thematically coded to extract key findings. Quantitative data from the survey underwent statistical analysis to reveal trends and correlations. After synthesising findings from the literature review, workshop discussions, and survey responses, key recommendations were formulated to enhance intergenerational collaboration within the raw materials sector. Tailored to address the specific needs and challenges identified by stakeholders, these study recommendations aimed to cultivate a more inclusive and collaborative environment for all generations involved in the raw materials industry. In subsequent chapters, the findings of the research are presented and the implications for stakeholders in the raw materials sector are discussed, along with actionable recommendations for improving intergenerational collaboration in this economic sector.

This study classifies youth as young professionals within the raw materials sector who are in the age range of 18-35 years old. This consideration helps to account for the substantial age variations present across various socio-cultural, institutional, economic, and political contexts. The justification for this age range is supported by a Eurostat study [27], which determined that, in 2022, young individuals across the EU moved out of their parental homes on average at the age of 26.4 years. However, this average fluctuates amongst EU countries with the Nordic and Baltic regions averaging between 21-23 years, while the southern and eastern countries range from 30-33 years. In addition, according to the United Nations [28], individuals of up to 35 years old are seldom seen in official political youth leadership roles. In around a third of all countries, the eligibility to participate in national parliament begins at 25 years or older. Moreover, it is a widespread custom to regard a politician as 'young' if their age falls between 35 to 40 years.

3. Results

The following sub-chapters provide a concise summary of the results of the workshop and survey used for this study on the role of youth within the raw materials environment.

3.1. Workshop Results

During the two-hour workshop, primary themes were centred around youth engagement in the raw materials industry, especially concerning critical raw materials (CRMs), and its significance in achieving the United Nations Sustainable Development Goals (UN SDGs). The importance of offering opportunities for young people to participate in governance processes that form decisions in the sector was highlighted. Emphasis was also laid on resource management practices complying with fundamental global standards that close existing transparency and inclusivity gaps. The first speaker, from the governance pillar, provided insights from the United Nations Economic Commission for Europe's (UNECE) Resource Management Young Member Group (RMYMG). The RMYMG is a subgroup of the UNECE Expert Group on Resource Management (EGRM). The subgroup is currently engaged with EGRM's work, focusing on developing and implementing the United Nations Framework Classification for Resources (UNFC) and the United Nations Resource Management System (UNRMS). The aim of this young group is to ensure intergenerational equity in resource management while maintaining environmentally sound and socially responsible practices. Including a broad spectrum of stakeholders, representing youth, including those with little professional experience, ensures intergenerational justice. RMYMG provides a platform where members can gather first-hand experience within the functions of the UNECE's EGRM and monitor the inclusion of youth and intergenerational collaboration aspects.

The speaker from the business pillar explored the evolving landscape of mineral processing technologies, with a specific emphasis on the role of youth and their potential on providing innovative approaches in the mining industry. The highlight was given to the transition from traditional, mining-focused linear innovation to alternative disruptive innovation models, underpinned by key technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI). The potential for the youth to instrumentalise their adaptable abilities to find solutions in the minerals industry was underlined in a fast-developing world. The discussion also touched upon the knowledge triangle of education, innovation, and entrepreneurship, highlighting how their implementation by institutions like the EIT RawMaterials can play a crucial role in fostering more learning and funding opportunities for young professionals. The speaker emphasised how exposure to entrepreneurial courses, a startup-friendly network, and support in mitigating financial risks motivated young raw materials experts, along with numerous peers, to deeply engage with the European mining industry by leveraging the resources provided by EU funding bodies, such as the EIT Raw Materials.

The conservative tendencies of the mining industry, especially in older mining regions in Europe, were addressed by the speaker from the academia pillar. The speaker confirmed that young researchers bring fresh perspectives and innovative ideas into the scientific discourse. The active involvement of youth in academic institutions fosters interdisciplinary collaboration, bridging gaps between traditional disciplines and enabling holistic approaches to mining challenges. The research on the involvement of youth in the rather conservative mining industry has played a crucial role in creating new knowledge paths as well as communicating research with the broader public. This can be especially helpful in managing Social Licenses to Operate (SLO) and include long-term sustainable practices in the revitalisation of the European minerals and metals industry. Increasing transparency through improving accessibility and terminology standardisation of old natural resource reports was also mentioned as a key principle to follow for sustainable growth. Building on the capacity of policymakers to best make use of natural resources of a region, as well as assess these resources under the UNRMS framework, was another key action point brought up by the speaker. The linearity of the mining sector and the challenge of providing the right and more industry-applied education to youth entering the sector were posited as potential challenges, as well as the lack of intersectional knowledge-building in the mining sector

Table 1: Key shortlisted barriers to intergenerational collaboration in the raw materials sector (adapted from Nurhas et al., 2019 [30]).

No.	Key shortlisted barriers to intergenerational collaboration in the raw materials sector
1	Lack of career experience
2	Lack of motivation
3	Lack of shared (financial) resource
4	Lack of a supportive social environment
5	Lack of technology access
6	Lack of time for collaboration
7	Technological complexity
8	Stereotype of geology/raw materials field (e.g., oil and gas exploration)
9	Hierarchical ladder

on cutting-edge software and machine learning tools caused by departmentalisation at universities.

The speaker from the civil society pillar explored the important role of youth in addressing wider environmental issues, particularly emphasising the concept of planetary boundaries and Roman Krznaric's notion of being a "good ancestor" [29]. The youth were identified as key agents in addressing the urgent problems of overconsumption, resource extraction, and waste generation for future generations. In this context, ecological economics was proposed as a significant field of study, offering an alternative to neoclassical economics. The speaker shed light on the partial global success of decoupling carbon emissions from economic growth, querying this achievement with the inability to disengage material consumption. Poor management of mine waste streams such as inadequately built tailings dams came under scrutiny, along with their repercussions on nearby population and especially to indigenous communities in Europe living in a greater symbiosis relationship with nature than modern societies. The speaker underscored the significance of community participation and approval with new mining projects in Europe and beyond. The highlight on the youth's role in leading the charge towards a more sustainable future was also given, aligning it with the youth's innovative perspectives and dynamic energy. This approach not only embraces youth inclusion in civil society actions but also underscores the significant contributions that youth can make towards a global sustainable development and environmental protection.

These workshop findings were collated thematically and compared with prominent barriers to intergenerational collaboration identified by Nurhas et al. (2019) [30] in a cross-sectional study. Nine key (and top) barriers for intergenerational collaboration were shortlisted for the raw materials sector, which are summarised in Table 1.

3.2. Survey Findings

The aforementioned list of nine barriers was used to support the survey [Appendix C and D]. Survey participants were instructed to provide their top three barriers to more youth representation and intergenerational collaboration in the raw materials sector. The respondents were also allowed to provide their own textual responses in the "Other" option. The analysis of the multiple-answer question looks at the overall responses first, then delves into the answers of the two age subsets (younger between 18 to 35 years old and older than 35 years old). Among the total 43 responses, the most commonly selected barriers were: 1) Hierarchical Ladder: selected by 26 participants, accounting for 60.5% of the responses, this option was the most prevalent barrier hindering intergenerational collaboration in the raw materials sector; 2) Lack of Career Experience: chosen by 24 participants, amounting to 55.8% of the total responses, the second most selected and logical barrier; 3) Lack of a Supportive Social Environment: selected by 19 participants, adding up to 42.2% of the responses, this option was third most popular; and 4) Lack of Shared (Financial) Resources: opted by 18 participants, equating to 41.9% of the responses. Proceeding with the subset analysis of the youth participants (18-35 years old), the top four selected barriers were consistent with the overall responses with 64.5% selecting "Hierarchical Ladder" as a significant obstacle to youth representation and collaboration, 67.7% selecting "Lack of Career Experience", 45.2% of total answers provided by the youth subset chose "Lack of Shared (Financial) Resources", and 41.9% of younger participants' responses opted "Lack of a Supportive Social Environment". On the other side of the sample, the 35 years old or older participants' perceived barriers varied slightly, with the "Hierarchical Ladder" and "Lack of Supportive Social Environment" identified as barriers by 54.5% and 45.5% of older respondents, respectively. In addition, a notable selection among older participants was "Lack of Time for Collaboration", with 36.4% of responses. It should also be noted that under the "Other" option, many participants provided additional observations of a broader range of perceived challenges within the raw materials sector, such as vague views and standards from the youth on global issues (e.g., climate change), and their strong opposition against the traditional mining sector).

The following open-ended question on how academia, industry, civil society, and/or governance can actively involve youth in decision-making processes related to raw materials received diverse perspectives and recommendations. Based on a thorough analysis, the identified top five common suggestions go under the following overarching topics: 1) Dedicated Platforms for Youth Engagement, emphasised mainly on the necessity to create more dedicated platforms and/or forums where youth can actively engage, voice their opinions, and participate in discussions on raw materials-related topics; 2) Promote Youth Representation in Decision-Making Bodies, where many respondents stressed on the importance of ensuring youth representation in decision-making processes relevant to raw materials, including actively involving youth in these processes where stakeholders can ensure diverse perspectives and consider youth voices and their longer-term future; 3) Provide Opportunities for Mentorship and Knowledge Exchange, highlighting the significance of peer-to-peer mentorship programs, knowledge exchange initiatives, and platforms for interdisciplinary engagement; 4) Enhance Communication and Awareness, including suggestions on the importance of organising thematic workshops, educational events and training, and outreach programs aimed at

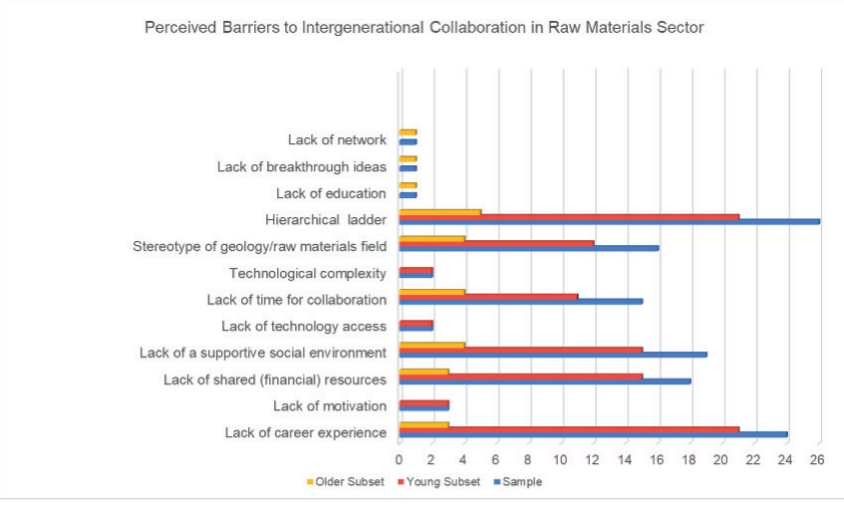

Figure 1: Perceived barriers to intergenerational collaboration in the raw materials sector.

educating youth about the raw materials sector's significance, opportunities, and challenges; and 5) Create Safe Spaces for Youth Engagement, by providing safe and inclusive spaces for youth to voice their opinions without feeling judged. Many respondents advocated for the establishment of environments where young professionals can freely express their ideas, contribute to discussions, and collaborate with peers without judgment based on age and career stage. The latest suggestion was very popular amongst the youth, whereas the older subset focused more on platforms to enhance knowledge exchange. Out of the 29 responses received, the subset representing participants over 35 years old, provided a similar perspective on improving intergenerational collaboration within the raw materials sector, mainly related to advocacy for youth involvement and education and mentorship. However, a common suggestion provided solely by the older subset of participants relates to the Recognition of the Value of Intergenerational Collaboration, highlighting the value of intergenerational collaboration in leveraging the experience of older generations while incorporating fresh and disruptive perspectives from younger professionals.

The last open-ended question sought participants' perspectives on strategies that can be implemented to ensure the scalability and widespread adoption of innovative solutions for the raw materials sector proposed by youth. A total of 21 responses were received, with 8 replies from the older participants and the remainder from the younger subset. Therefore, the analysis of these replies is divided according to the two selected age ranges. From the older subset (older than 35 years old), respondents emphasised the importance of actively involving younger work colleagues in strategic processes early on, providing them access to decision-making processes, and fostering a culture where youth perspectives are valued and integrated into organisational strategies. Other suggestions included the establishment of dedicated acceleration programs for young entrepreneurs, philanthropic funding initiatives, and bursaries/startup funding schemes tailored to support youth-led projects and initiatives. Lastly, the remaining responses from the older subset touched on networking events or platforms for idea pitching, feedback, and generational collaboration, in order to facilitate connections between youth innovators, industry experts, investors, and potential partners. On the other end of the sample, the youth subset (35 years old or younger) highlighted the importance of creating support networks and organising innovation challenges in collaboration with companies to provide opportunities for youth to implement their ideas, promote startup entrepreneurship, and foster the adoption of innovative solutions. Moreover, a common suggestion from the younger respondents consisted of mainstreaming youth participation in decision-making tables at various levels (municipalities, enterprises, universities), fostering environments for startups and incubators, and discussions between generations, networking platforms, and forums for young entrepreneurs to connect with industry experts, investors, and potential partners. Additionally, younger respondents suggested more publicity for youth-led solutions to raise awareness and facilitate widespread adoption. Capacity building was also amongst the recommendations, with a focus on providing more financial resources and training programs for young entrepreneurs.

4. Discussion

The discussion aims to present a re-evaluation of the data collected via workshop and survey findings that shed light on how the youth, particularly in Europe, perceive their opportunities and motivation to participate in the raw materials sector. A significant percentage of the youthful demographic feel marginalised and encounter many obstacles in making an influential difference in their future, underscoring the need for increased participatory initiatives to achieve intergenerational justice [31]. Over the past decade, Europe has seen a surge in resource management policies aimed at securing vital raw materials and promoting sustainability. Key initiatives include the Raw Materials Initiative, fostering innovation through the European Innovation Platform (EIP) on Raw Materials, and partnerships like EIT RawMaterials. The Critical Raw Materials (CRMs) List identifies essential materials, while the European Raw Materials Alliance (ERMA) works to diversify supply chains. Recent acts like the Net-Zero Industry Act and Critical Raw Materials Act, along with regulations promoting sustainable production and consumers' right to repair, highlight Europe's commitment to a secure and sustainable raw materials landscape [32]. However, intergenerational collaboration, although crucial for long-term sustainability, has not received as much attention given the increasing demand for young professionals in the raw materials sector, especially on innovative and disruptive approaches to foster sustainable resource management.

The following paragraphs discuss potential solutions and recommendations that could overcome these barriers.

Navigating through steep hierarchies within professional sectors seems to be a challenging task for many young professionals within the European raw materials sector, especially in academia. Frustration and lack of motivation commonly result when they do not have the opportunity to conduct research in specific areas that are most relevant for their future. Also, in business, hierarchical structures tend to impede their access to opportunities and limit their ability to contribute meaningfully to their field [13]. Collaborative and intergenerational platforms, such as RMYMG, provide young professionals with insight into European resource management governance that would typically require years of experience to gain. The initiation of accessible youth groups and programs that allow collaboration on a higher-level playing-field could provide first-hand insight into the practices and unique challenges within this field, cultivating a collaborative and non-intimidating environment for youth. Such collaborative platforms should be balanced, enabling both young and senior professionals to learn from each other, thus fostering a climate of mutual respect and collaboration. The positive effects of enhanced collaboration aligns with several studies [13] where experienced professionals can mentor and share knowledge with younger members, and in return, these younger individuals could bring fresh, innovative ideas to the group.

Young professionals often face a paradox: they cannot gain experience without opportunities, and opportunities are often linked to prior track record experience in very specific fields [33]. When organisations demand substantial experience even for junior or entry-level positions, this can discourage and disappoint young talents eager to enter the sector. While industry-specific expertise is undeniably beneficial, the rigid expectation of an elaborate academic and professional pedigree may overlook the value of diverse knowledge and

skills that potential candidates might have gained through unconventional or less formal educational means, especially in a globalised world with multiple online knowledge sources. The workshop indicated that adjusting the traditional recruitment process (e.g., knowledge-based interviews) could offer potential resolutions for specific job positions. Focusing on the applicant's knowledge rather than their academic and/or professional credentials could give a more accurate insight into their potential on-the-job performance. This recruitment optimisation offers the opportunity for candidates who may have obtained their knowledge through non-traditional or experiential learning methods to demonstrate more accurate suitability for the role.

The results also point out that young people have a need for a safer environment to make their voices heard without being scared or feeling judged by seniors. Especially those who chart successful paths, typically benefit from clear communication channels that allow feedback, appreciation, and recognition in anonymous or non-judgemental environments. The relevance of such spaces is further confirmed by studies on youth collaboration that indicate a higher desire to engage in meaningful dialogue in younger generations [34, 35]. They ensure that the voices of youth are heard and respected in discussions concerning their well-being and future prospects.

Opportunity inequalities persist in the raw materials sector [36]. While youth possess unique perspectives and innovative ideas, their contributions may sometimes be overlooked or undervalued within traditional working structures. Nonetheless, the evolving landscape of youth activism in Europe holds immense potential. With the rise of digital platforms, social media activism, and youth-led initiatives, young people are increasingly leveraging their collective power to drive positive change and influence policy decisions related to mining, raw materials management, and broader environmental and social justice challenges [37]. However, only economically privileged youth can benefit from unpaid highly competitive internships, time-intensive voluntary work, and personal networks that allow more youth participation in the different societal pillars. Civil Society organisations have highlighted a significant lack of representation within the raw materials industry in influential businesses and academia pillars [36]. This is notable as many of the communities most impacted by inadequate resource management are indigenous communities and other marginalised groups. These communities do not have the same modern-society resources as, for example, economically-privileged youth. In this context, initiatives like the European Union's Structured Dialogue, Erasmus+ Programme, and European Solidarity Corps play pivotal roles in providing platforms for young Europeans to voice their concerns, participate in policy-making processes, and engage in meaningful actions towards a more sustainable and equitable future for all [38]. Through these initiatives, European youth are empowered to contribute their energy, creativity, and passion to address the complex global challenges facing their communities and their future. There is also a current concern where niche funding opportunities tend to merely target young individuals already involved in specific ecosystems, like the EIT and the UN ecosystems.

The apparent lack of interest in natural resources management [39] sharply contrasts with the high levels of climate advocacy and action among the youth [40]. Currently, there seems to be little empirical evidence on the state of intergenerational collaboration in different industries across various cultural, geographical, economic, social, and political contexts, and potential strategies to overcome gaps [41]. The question is how youth can be engaged more effectively if jobs and salaries in the geoscience field, particularly academia, are less attractive than in private businesses inside and outside of Europe [42]. The job roles of Research & Development in geosciences for the green transition may create numerous opportunities in emerging fields such as critical raw materials, circularity and eco-design. The challenge lies in making these opportunities more inclusive for talented individuals who inhibit the motivation but lack the privilege of having the appropriate network or resources to reach it.

The literature review and workshop lead to the realisation that there is little empirical evidence or knowledge on intergenerational collaboration in the European raw materials sector and strategies to increase it. Intergenerational collaboration strategies from different industries across various cultural, geographical, economic, social, and political contexts can provide best practices that the global raw materials sector could benefit from to achieve a more resilient and sustainable future [43]. Lastly, the survey results included suggestions and recommendations from youth and older generations from other countries where youth inclusion is more prominent than in Europe. Promoting the European raw materials environment to emerging professionals outside the EU and enhancing international collaboration through international conferences, youth delegations, and round tables have been mentioned as key solutions. However, the challenge is to raise awareness among individuals who are not part of these exclusive professional networks and to provide the financial and outreach support to enable them. That way, expertise from diverse fields of different work, education, and cultural settings can be drawn into a more holistic and inclusive raw materials field.

Traditionally known barriers such as a lack of network, lack of breakthrough ideas, lack of education, lack of technological capacity, and lack of motivation, seem to be less obstructive in this context as they were the less selected barriers in the survey, supported by youth innovation and readiness to engage. Higher education institutions, internships, and training often provide young professionals with extensive networking opportunities. Furthermore, the inherent cross-generational synergy of this industry sector fosters a culture of connectivity, allowing emerging professionals to associate with their experienced counterparts. European academic institutions, globally considered among the finest, supply a well-educated workforce in raw materials and allied disciplines, thus dispelling the idea of a 'lack of education'. New young professionals, enriched with specialised qualifications, enter the European raw materials sector ready to engage. The survey results also do not indicate a 'lack of breakthrough ideas'. Innovative ideas in the raw materials sector often arise in business-oriented universities, but often do not get translated into marketable practices, especially concerning highly-competitive funding instruments. This last remark also highlights the importance of transposing the often well-established intergenerational collaboration from academia into the other societal pillars of governance, business and civil society. The barrier of 'lack of technological capacity' is surpassed by the inherent technological fluency of today's younger generation in a more and more interconnected world. As digital

natives, the youth's adeptness in embracing rapidly evolving technological trends harmonises with the sector's growing reliance on digital innovations and technological advancements.

5. Conclusions

The scope of this research study was to evaluate the state-of-the-art concerning intergenerational collaboration in the geosciences field, particularly in the raw materials sector, as well as to assess a thematic workshop and survey results from a broader expert audience, within the IRTC24 conference, to delve into discussions on the underexplored potential for enhancing youth inclusion, intergenerational collaboration, and ultimately, intergenerational justice within this field considering four societal perspectives of governance, academia & research, business, and civil society. Some concluding remarks include the identification of the most prominent barriers for youth representation in the raw materials sector being (1) the hierarchical ladder, (2) the lack of career experience, (3) the lack of a supportive social environment, and (4) the lack of shared financial resources.

Key recommendations to overcome the aforementioned barriers for more youth representation in the raw materials sector include; (1) providing more opportunities for mentorship and knowledge exchange through established intermediary stages, such as mentorship tracks and introductory positions, while youngsters conclude academic paths or have recently graduated. These bodies, integrating both young and senior professionals, can bridge the gap between different generational experiences and align interests as well as innovative market demands; (2) institutions should acknowledge and give space for the youth learning curve to start without requesting for a mature track-record, (3) creating safer environments for intra- and intergenerational engagement by appointing youth representatives or envoys for youth affairs within governmental bodies, companies, and civil society organisations and make sure that young professionals can freely express their ideas, contribute to discussions and collaborate with peers without feeling judged; (4) increasing financial funding to address budget constraints to enhance intergenerational collaboration, either through youth delegations, better-paid internships and junior positions, as well as more advertisement on funding instruments targeting youth who lack financial resources; (5) enhancing awareness and communication of funding instruments and programmes by offering more targeted guidelines and roadmaps for EU and international funding and collaborative opportunities for young raw materials experts, thus providing a clear direction and access to resources.

Lastly, the current study presented a few work limitations that can be translated into future work recommendations, such as a more representative workshop and survey participants sample to achieve a more qualitative and thorough youth and senior insights, running online or physical interviews with a considerable sample size of institutions representing the different societal pillars (governmental bodies, academic institutions, industry players, and civil society organisations), and more funding resources would improve the overall quality of this study with, for example, more accredited and licensed software for the data curation and processing of the workshop findings and survey results.

Supplementary Materials: The following supplementary materials are available online via the following links:

Appendix A: *Workshop Concept Note and Information (pdf)*
Appendix B: *Survey (pdf)*
Appendix C: *Survey Results (xsl)*
Appendix D: *Detailed Survey Results (pdf)*

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