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Collaborating on ESG consulting, reporting, and communicating education: Using partner maps for capability building design

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Given the rising demand for environmental, social, and governance (ESG) talents, this study aims to provide a multidisciplinary outlook of specific capability requirements for ESG talents, focusing on the use of ESG and carbon information, thereby providing a roadmap for ESG education. Following design science framework conventions and running design workshops that integrate design thinking of "how might we" design questions, literature analysis, and expert interviews across disciplines, this study presents findings regarding three main activities—consulting, reporting, and communicating. Based on the iterations of design workshops that adopt a circular economy-based partner map design canvas for stakeholder analysis with procedures such as expert interviews and literature analysis, three partner/capability maps were generated to map stakeholders and explore the capabilities needed. ESG and carbon information digital and data skills emerged as the core capability to complete all the three tasks. A conceptual framework—a Smart System of ESG and Carbon Information—is proposed to summarize planning, operating, and communicating with ESG and carbon information, along with high-level organizational actions and talent capabilities. It identifies the building blocks of an ESG operating system within an enterprise to engage various stakeholders for value-creation collaboration. Despite the limitation of a lack of comprehensive review and limited geographic and disciplinary representation, this study provides a roadmap for enterprises and universities to explore and define talent requirements and create specific education and training programs.

KEYWORDS

ESG, corporate accountability, decarbonization, carbon accounting, digital transformation, strategic foresight, capability building, circular economy

1 Introduction

Higher education plays a vital role in preparing students with knowledge and skills for both work and life. To achieve the UN Sustainable Development Goals (SDGs), it is essential to build students' capabilities to transition to a circular economy. While it is beyond the scope of this article to discuss the role of students as consumers, prosumers, or producers of higher education (Demiray and Sever, 2011; Bunce et al., 2017; Hynes, 2017), it is important to design the curriculum of Education for Sustainable Development (ESD) in line with the UNESCO roadmap (UNESCO, 2020) by putting human responsibility at the center. Collaboration between higher education and lifelong learning communities is crucial,

and stimulating both the demand and supply for ESD and SDG knowledge should thus prepare human society to manage climate change and the COVID-19 pandemic recovery challenges toward a net-zero carbon-neutral future.

1.1 Demand for ESG training and education

The demand for knowledge on environmental, social, and governance (ESG) is growing as companies face mounting pressure to report their SDG performance in climate and environmental impact. ESG, which is instrumental for sustainable finance (Archer, 2019), often takes the form of metrics and reporting to account to stakeholders and shareholders beyond monetary values (Esty and Cort, 2020). Various academic handbooks (e.g., Câmara and Morais, 2022) and self-help books (e.g., Bradley, 2021; Trefz, 2023) have been published, covering topics such as ethical management (Dathe et al., 2022), advanced quantitative methods (Shmatov and Castelli, 2023), and ESG technology (Bril et al., 2023) (For more information on ESG, please see the first subsection of the Supplementary Material).

ESG talents are in high demand. A leading accounting firm has responded by creating an ESG academy and hiring 100,000 talents to help businesses (DiNapoli, 2021). With growing expectations of ESG-focused institutional investment, a survey indicated that ESG is shaping the future of finance (PwC, 2022). As capital markets and firms prepare for ESG readiness, higher education needs to equip students with relevant knowledge and skills.

Chinese demand for ESG talents is strong. Chinese enterprises face pressure to prioritize ESG and green finance practices, especially because of China's carbon neutrality targets. According to a report by PwC China, the United Nations Development Programme, and the China Chamber of International Commerce, 89% of Chinese enterprises are aware of the SDGs; 69% have publicly mentioned the SDGs; and 42% do not know how to evaluate them (PwC China et al., 2020). Global enterprises prioritize responsible consumption and production (SDG 12) and decent work and economic growth (SDG 8). However, Chinese enterprises prioritize good health and wellbeing (SDG 3) and quality education (SDG 4).

Moreover, the People's Bank of China has estimated that China would incur 139 trillion yuan (US$21 trillion) to achieve carbon neutrality goals by 2060, including establishing carbon trading markets and international green finance standards (Tang, 2021). China's Action Plan for Carbon Dioxide Peaking Before 2030 requires listed and bond-issuing companies to disclose their carbon emissions in accordance with environmental information disclosure laws (Xinhua, 2021). It also emphasizes training and education for students and party cadres by strengthening the industry–education exchange. Chinese higher education must prepare students to be SDG-informed, ESG-ready, and carbon neutrality-ready.

1.2 Demand for ICT solutions for emission management

The UN's specialized agency for information and communication technologies (ICTs), the International Telecommunication Union (ITU), announced the green digital transformation standards at COP27 in 2022, which not only accounts for carbon emissions for the ICT sector but also provides guidance on how to develop ICT solutions for other sectors to achieve net zero transition (ITU-T, 2020; ITU-T, 2022; Johnson, 2022). Moreover, as evidenced by the most recent standardization efforts by the Internet Society of China (2022) on defining information system requirements of China's "Carbon Peak Carbon Neutral Management and Service Platform," digital technologies are expected to contribute to climate change solutions (Dwivedi et al., 2022). Thus, ESG-ready talents must be digital-ready, with practical skills in designing, executing, and managing data-driven solutions.

1.3 Supply of ESG education

Several recent studies have identified education barriers as major obstacles to the development of ESG practice. An early-access paper on Polish ESG practices suggested that the education of all participants in investment processes is a prerequisite for success (Dmuchowski et al., 2023). Moreover, a study published in *Accounting Education* proposed an ESG learning model for accounting educators to understand threshold concepts of corporate externalized costs (Sheehan et al., 2022). A study of individuals in the United Kingdom and the US revealed four major misconceptions about socially responsible investments, calling for education to promote such investments (Meunier and Ohadi, 2022). In addition, based on a sample of 17 Canadian universities, a study on the current state of ESG pedagogy within undergraduate finance courses found that little attention is given to ESG, but non-traditional teaching avenues such as student-managed investment funds can be employed to meet the industry demand for ESG-related skills (Oldford et al., 2022). Furthermore, research on Taiwan's higher education's carbon ESG development strategy suggested the establishment of emission-reduction professional training and courses, as well as region–university collaboration and non-profit organization value alignments (Chan and Hsieh, 2022). Finally, a Chinese-language study documented a university's experience in leveraging alumni resources to build a "Government-Industry-Academia-Research-Use" postgraduate training mode [sic] (Wang and Chen, 2022).

While these studies contributed to the novel research area (all published in 2022), none of them provided a multidisciplinary outlook of specific capability requirements of ESG talents. It is vital to specify the capability requirements of ESG- and digital-ready talents that can help enterprises in consulting, reporting, and communicating SDG- and ESG-related activities. To identify such requirements, this study formulates the following research question from the perspective of stakeholder analysis:

How can higher education prepare students as future ESG talents for enterprises and their stakeholders, including using digital technologies to achieve SDGs and carbon neutrality goals?

1.4 Focus on stakeholder analysis and digital technologies

Based on our previously published conference papers on a research and education agenda based on a bibliometric analysis (Liao et al., 2021) and a roadmapping exercise (Zhou et al., 2021), this study aims to fill

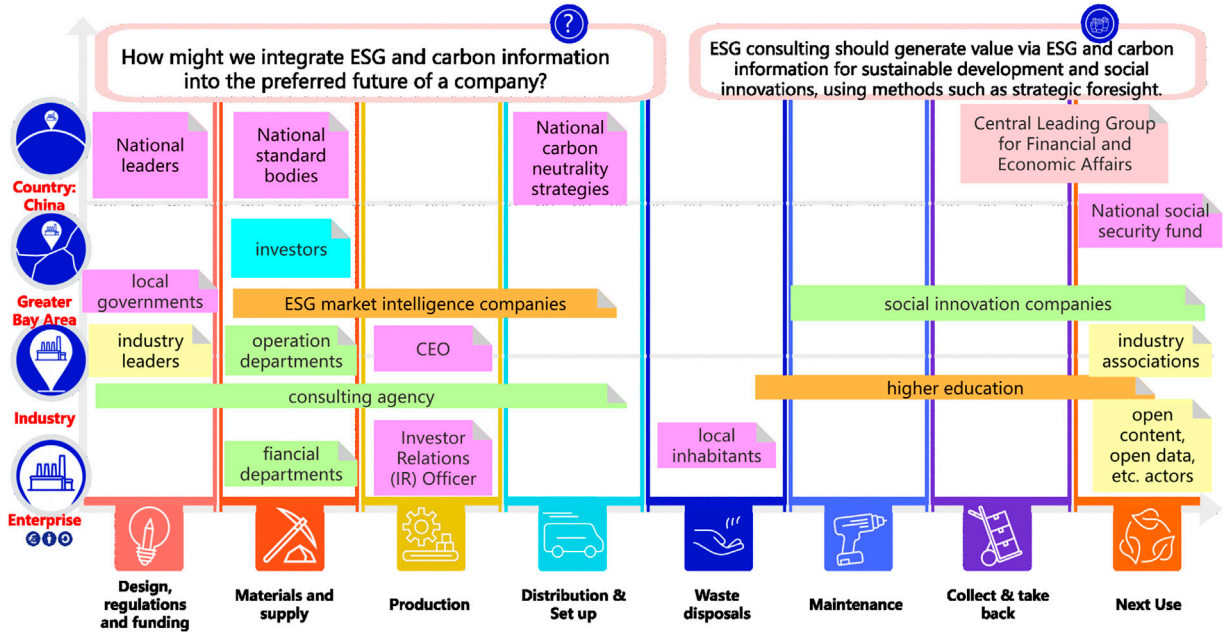

FIGURE 1
Partner map for ESG consulting (based on the blank canvas provided by Circulab (2020) through Creative Commons License Attribution-NonCommercial-ShareAlike 4.0 International).

the research gap by answering the above question by conducting a stakeholder analysis, echoing the much-needed paradigm shift from shareholder-only to stakeholder-inclusive.

Digital technologies research guides us to apply the design thinking of smart customer experience using smart systems, which can enhance satisfaction and reduce perceived risks (Roy et al., 2017). By envisioning ESG talents' career journeys in helping enterprises with their ESG capacity, this study explores the data and digital capability requirements for ESG actions. For enterprises to engage stakeholders such as consumers, clients, investors, and regulators using digital technologies and smart services, this study focuses on the smart system experience of these stakeholders as potential collaborators in producing and consuming ESG-related knowledge.

2 Methods

This section describes how design workshops are designed and executed along with other data.

2.1 Research design and method

Following the design science framework conventions that have been applied in information system research (March and Smith, 1995; Hevner et al., 2004; Bertella et al., 2021; Eisape, 2022; Fatima et al., 2022), this study ran design thinking workshops to identify the gap between theory and practice and seek opportunities that lead to collaborative solutions. Often, the use of design canvas such as platform canvas for building and evaluating business models can be theorized and justified by natural and social science knowledge, as evidenced by artificial intelligence (AI)-enabled solutions design research (e.g., Brecht et al., 2021; Fatima et al., 2022). Thus, the design workshops for this study comprise building and evaluating activities on a design canvas and theorizing and justifying with multidisciplinary knowledge from expert participants, along with their suggested literature.

The Partner Map Canvas provided by Circulab (2020) is used for the circular economy and stakeholder analysis, both of which are suitable for the research purpose to envision and explore ESG capabilities for a circular economy based on stakeholder analysis. The canvas lays out different steps of the value chain in a circular economy, including design, materials, manufacturing, distribution, waste, repairing, take back, and next use, as illustrated in Figure 1 by the x-axis. It also reveals different levels of stakeholders (from local to global), as illustrated in Figure 1 by the y-axis. Other canvases were considered (Hofmann et al., 2017; Daou et al., 2020; Lagrasta et al., 2021; Lauten-Weiss and Ramesohl, 2021; Salvador et al., 2021; Albastroiu Nastase et al., 2022); however, they focus more on designing specific business models or solutions for specific problems and thus are not suitable for this study.

The Partners Map Canvas provides a collaborative form of stakeholder analysis in several ways. It allows design workshop participants to appreciate the power of cooperation. The concept of digital cooperation (United Nations, 2020) was suggested as one possibility. It also allows participants to identify the stakeholders and then reflect on their needs for value creation. If the participants come from more industries or disciplines, more diverse and richer stakeholder profiles can be gathered,

along with their needs. The concept of human–robot interaction (Dautenhahn, 2022) was suggested to reflect stakeholders' needs in smart services and digitalization.

2.2 Design workshop process and iterations

To collaborate effectively for the stakeholder analysis, the design workshop participants were instructed to identify and envision stakeholders as potential partners. The overall process was as follows.

- First, the participants began with a "how might we" (HMW) design question defined by the authors.
- Second, they were asked to identify relevant stakeholders for each step of the value chain in the circular economy.
- Third, they were asked to identify and organize more stakeholders at different levels, along with their needs for ESG actions.
- Fourth, they were asked to envision digital cooperation or ICT solutions to meet the identified needs of the stakeholders.
- Finally, they were asked about the knowledge and capabilities needed to design and execute such digital cooperation and ICT solutions.

From **partners** to **capabilities**, iterations were encouraged by exchanges of ideas among participants, including any experiences or literature they find relevant. These exchanges become mini policy reviews and expert interviews.

2.3 Data and materials

Based on policy analysis and expert interviews that focus on ESG value creation and value chains, three ESG partner/capability maps were generated for three main activities—consulting, reporting, and communicating. Five design thinking workshops were held from October 2021 to November 2022 to revise and improve these partner maps. To facilitate cross-disciplinary collaboration, the workshop participants were from related disciplines and professions, such as management, accounting, finance, information science, public administration, public relations, communications, and data sciences. For more detailed information on the participating institutions and disciplines, please see the second subsection of the Supplementary Material.

Given the crucial role of China in green finance, ESG efforts, carbon neutral policies, and climate change actions (Dargusch, 2017; Wang and Wang, 2017; Normile, 2020; Gao et al., 2021; Zhang et al., 2021), the study focused on the Guangdong–Hong Kong–Macao Greater Bay Area (Greater Bay Area). Inspired by the notion of open innovation through cross-disciplinary industry–academia collaboration (Dieguez et al., 2020), it is vital to further advance ESG education through the value chain and across disciplinary boundaries so that valuable information and knowledge exchanges for ESG activities can be improved.

Finally, to integrate all three ESG partner/capability maps as higher-level thinking of enterprise capacity, the authors developed a framework called Smart System Requirements of ESG and Carbon Information.

3 Results

This section presents three partner/capability maps.

3.1 ESG consulting capability map

In general, consulting generates strategic foresight (Buehring and Bishop, 2020) and provides enterprises with innovative strategies to transform their organizations (Simon and Kumar, 2001), including digital and information technology innovations (Swanson, 2010). Their values include consultancy for positive impacts, ESG value creation, sustainable development, and social innovations.

How might we integrate ESG and carbon information into the preferred future of a company? Answering the HMW design question, Figure 1 depicts the importance of speculative design on the innovative use of ESG and carbon information in the outcomes of the partner/capability map. Enterprises can use the map to explore how ESG consulting fits in the circular economy value chain. The coordination of accounting and consulting professionals is essential to identify major ESG stakeholders in both the environment and people (e.g., workers and local inhabitants). To align with stakeholder interests, strategic foresight should synthesize the perspectives of different stakeholders, including governments, accounting professionals, and investors, to generate actionable scenario planning to improve ESG performance. Inputs and feedback from leaders and standard organizations are vital in building ESG value propositions. In the Chinese context, carbon emission database owners such as Carbon Emission Accounts and Datasets (CEADs) initiative can provide the raw data in shaping such stakeholder alignment across regional and sectorial partnerships. (CEADs, 2022).

ESG consulting skills thus require stakeholder alignment, management, strategic foresight, and scenario planning, as well as the use of digital and internet services throughout the circular economy value chain based on both ESG and carbon information.

To evaluate and complement the consulting capability map, this study reviews the relevant literature. First, consulting services can be provided to develop intelligent strategies for supply chains and operations using digital technologies, quantitative analysis, standardization, and qualitative performance evaluation (Ernst & Young, 2022). Advanced smart services can include supply chain remodeling, digital planning, supply-side optimization, smart factory, and digital logistics management. In this regard, the capability map has highlighted the importance of integrating ESG and carbon information into the technology roadmap of enterprise management. Such a roadmap should also be developed in conjunction with the latest development in supply chain finance and FinTech in China (Simon and Kumar, 2001; Swanson, 2010). Strategies on the future landscape of capital, technology, and supply chain can thus create stakeholder value and manage ESG-related risk factors, including supply chain resilience (Liao and Pan, 2021).

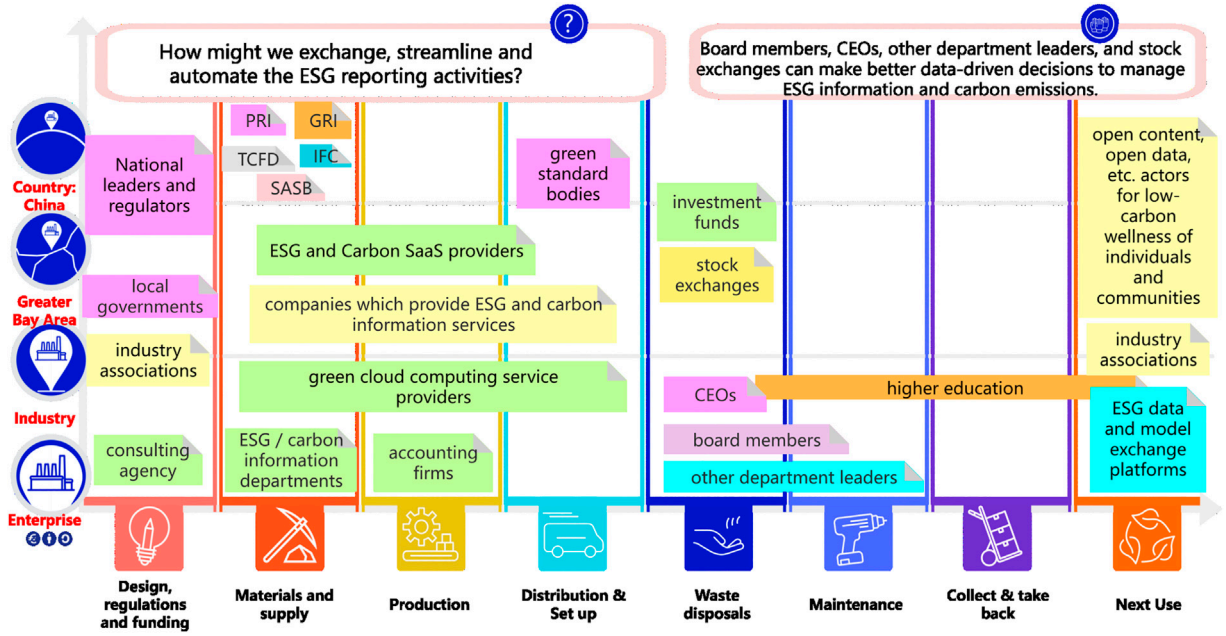

FIGURE 2
Partner map for ESG reporting (based on the blank canvas provided by Circulab (2020) through Creative Commons License Attribution-NonCommercial-ShareAlike 4.0 International).

The consulting capability map provides a critical assessment of a company's future in the evolving landscape of capital, technology, and supply chain.

3.2 ESG reporting capability map

ESG reporting requires both data and analytics to disclose relevant operations information according to well-recognized best practices and standards.

How might we exchange, streamline, and automate ESG reporting activities? Answering the HMW design question, Figure 2 illustrates the critical role of data: ESG data and analytics provide evidence-based reporting capability, thereby allowing stakeholders, such as board members, CEOs, and stock exchanges, to make informed decisions.

Stakeholders involved in the design, regulations, and funding of ESG initiatives include consulting agencies, industry associations, government leaders, and regulators. Staff or departments tasked with managing ESG and carbon information need to gather relevant operations and supply chain information. To produce ESG reports, they follow guidelines such as the UN Principles for Responsible Investment (PRI) initiative, Global Reporting Initiative (GRI), Task Force on Climate-related Financial Disclosures (TCFD), International Finance Corporation (IFC), and the Sustainability Accounting Standards Board (SASB) Alliance. The ESG reports can be donated to universities for educational use. Moreover, Internet and cloud service companies can help exchange, streamline, and automate ESG and carbon emissions data as part of operations management for better data-driven decisions.

One product was found to be a leading example in the Guangdong–Hong Kong–Macao Greater Bay Area (GBA) context of transforming complex and time-consuming ESG data collection processes (PricewaterhouseCoopers, 2022). It uses a visualized dashboard based on a cloud-based platform with both quantitative and qualitative inputs that are standardized for preparing ESG reports while ensuring the accuracy and reliability of ESG reports in compliance with the Hong Kong Exchanges and Clearing Limited. Its streamlined approach, focusing on data-driven and digital-transformation strategies, highlights the value of trustworthy data. The product features also confirm the organizational need to integrate diverse operation and supply chain data sources in an auditable and verifiable manner to provide both business insights functionalities beyond ESG report preparation.

Several challenges facing PwC clients were found to be generalizable for talent requirements during the design workshops. Data collection, analysis, and disclosure processes require both data science and project management skills. Integrating these skills can provide valuable benefits for companies to leverage digital technologies for ESG reporting and better operations. First, skills in gaining a systematic and comprehensive understanding of internal operations and external expectations depend on data capabilities in reliable and trustworthy data processes. Second, project teamwork requires skills in negotiating and transforming data across departments for auditable, verifiable, and useful data analysis. Finally, data storytelling capabilities are required to use timely and easy-to-understand dashboards for effective communication with targeted audiences or stakeholders.

In summary, ESG reporting capabilities should prioritize skills in collecting and disclosing operation-related data for supporting business actions and ESG activities. In addition, because cloud-based software-as-a-service (SaaS) is becoming popular in China, offering

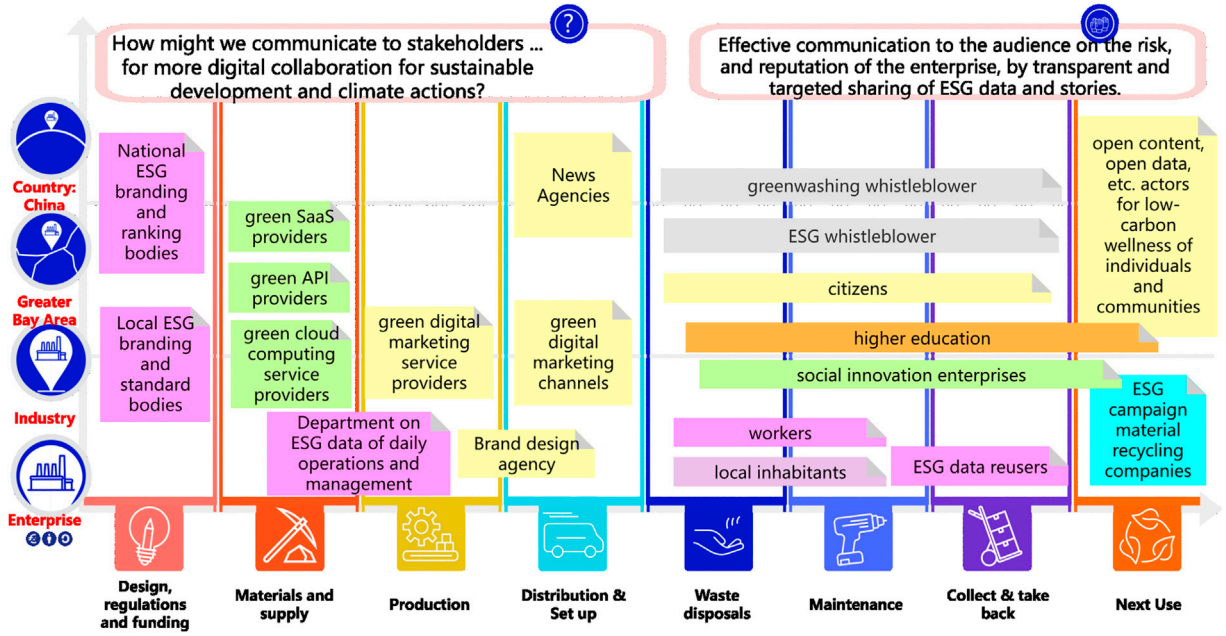

FIGURE 3
Partner map for ESG communicating (based on the blank canvas provided by Circulab (2020) through Creative Commons License Attribution-NonCommercial-ShareAlike 4.0 International).

ESG reporting services has great potential for green digital transformation innovations. This requires talents who are experts in both operations management (especially project management) and data science (particularly in ESG and carbon emissions).

3.3 ESG communicating capability map

ESG communication ultimately requires the green digital transformation of brand-building processes.

How might we communicate to stakeholders for more digital collaboration for sustainable development and climate actions? Figure 3 depicts the importance of smart customized storytelling to meet different stakeholders' needs and understand a company's ESG performance, which can be accomplished through various methods such as impact storytelling and resource sharing. With the growing prominence of digital channels (such as social media) for communicating stakeholders, citizen science (Cooperman, 2018) and social enterprise innovation projects can promote communicating and meaningful ESG data reuse through positive word-of-mouth (Liu and Liao, 2021), open content, open data, open data models, and open standards, thereby fostering tighter digital collaboration.

The PR Newswire ESG Communications Handbook, both the Chinese and English versions, is an excellent reference for enriching the ESG communication capability map (PR Newswire APAC, 2021). It defines ESG as a set of standards used by investors to evaluate a company's ESG performance, and it introduces international disclosure standards, such as PRI and GRI. It emphasizes the importance of effective ESG disclosure and communications in reducing risk, improving reputation, and creating long-term brand value. It also highlights the importance of consistent integration of ESG with a company's daily management and operations, confirming the role of data transparency in communication. It also argues for the engagement of both the upstream and downstream with audiences and stakeholders in the industry chain through various platforms and channels, which confirms the usefulness of using the circular economy partner canvas that demands the consideration of the value chain.

The handbook suggests that companies can begin their ESG strategy from the Investor Relations Officers (IROs). It emphasizes the importance of IROs to have the capability to articulate a sound ESG strategy, quantify disclosing information, and prepare executives to respond to stakeholders' concerns. In addition, ESG values and value propositions need to be communicated effectively, and it lists eight types of content for ESG-related press releases: 1) the announcement of annual ESG/CSR/Sustainability reports; 2) ESG visions, goals, and plans; 3) ESG awards; 4) inclusion of a key industry ESG index; 5) participation in partnerships, alliances, or campaigns with industry organizations; 6) ESG/CSR/Sustainability initiatives and outcomes; 7) ESG accreditation; and 8) research findings publications. Skills from disciplines of finance, public relations, and brand management thus require updates on ESG-related value proposition writing that communicate effectively with qualitative and quantitative evidence.

During one design workshop, a service prototype was designed based on the handbook. The prototype is an AI-assisted campaign planning service that creates ESG-related communicating stories and events using data gathered from social media platforms. To ensure effective and transparent ESG communication, sentiment analysis (or opinion mining) should be built based on an evidence-based model that prevents greenwashing activities and promotes

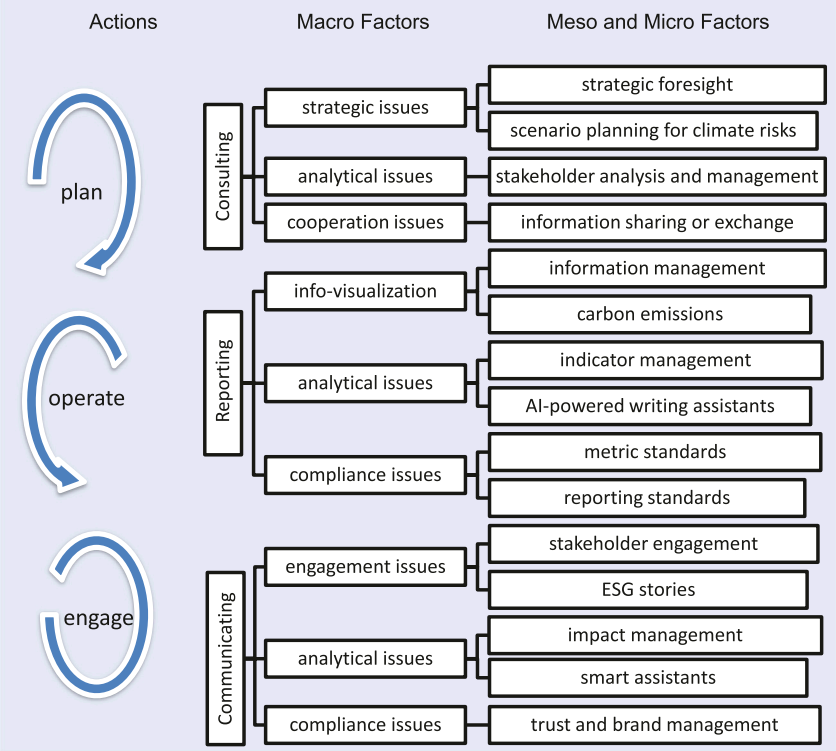

FIGURE 4
Smart system requirements of ESG and carbon information framework.

transparency (Uyar et al., 2020; Yu et al., 2020; Liao and Huang, 2021; Liao and Pan, 2021) for intelligent and sustainable user experiences.

The ESG communicating capability map reveals the importance of effective communication with stakeholders of companies, such as investors, local governments, national regulators, the media, and the general public, to exchange ESG stories, information, and data to build trust and support.

4 Discussion

This section discusses the results and usefulness of the study in specifying capabilities to meet industrial demand using a stakeholder analysis based on a design canvas that helped to gather both expert opinions and literature relevant to the GBA context.

4.1 Design of partner and capability maps based on collaborative stakeholder analysis

The main contribution of this study is the business model design innovations that optimize the positive impacts of digital platforms, as outlined in the latest ITU and ISC documents.

As a novel contribution to both the circular economy and ESG research and practice communities, the three partner maps have identified and connected important building blocks of an ESG operating system within an enterprise to engage various external stakeholders for value-creation collaboration. One associated contribution is the use of these partner maps as capability maps to explore ESG capabilities for education and training purposes; thus, these collaboration and capability requirements have empirical bases for stakeholder analysis.

More sophisticated capability roadmap exercises can be conducted in the future for more institutions in alignment with the UN Secretary-General's Roadmap for digital cooperation and the UNESCO roadmap for sustainable education. Such a partner/capability roadmap can create demand, cultivate talents, and innovative solutions with ESG and carbon information to achieve sustainable development and carbon neutrality goals.

4.2 Articulation of an integrated capacity framework based on the ESG capabilities

The study further integrated three ESG capability maps into a conceptual framework called a Smart System of ESG and Carbon Information, as depicted in Figure 4. By using the metaphor of operating systems to describe enterprises in need of an update to leverage ESG and carbon information for their operations, the framework highlights the actions of planning, operating, and communicating as a high-level enterprise capacity for sustainability

(see the left side of the figure). To achieve high-level capacity, talents are needed for consulting, reporting, and communicating capabilities in using ESG and carbon information to create values for stakeholders.

As the second contribution, the proposed framework connects the organizational capacity to upgrade a company to meet the requirements of capital markets that require ESG and carbon information as well as the capability requirements for ESG talents based on the collaborative stakeholder analysis of the study. In particular, by providing useful reports for higher education institutions to work with relevant industrial sectors, the framework maps high-level organizational actions to the respective ESG consulting, reporting, and communication services, which require human capital and talent to solve and accomplish. The proposed Smart System of ESG and Carbon Information framework provides specific requirements for higher education and ESG service providers. Collaboration across disciplines is needed, and partner/capability maps can help engage related professional and industrial associations to harness the potential of ESG and carbon information.

4.3 Limitations and future research directions

Although the design artifacts and conceptual framework are useful capability-building roadmaps for enterprises and universities to explore and define talent requirements to help organizations plan for, operate upon, and engage with ESG and carbon information, more work is required to achieve an education and training agenda that is actionable. Nevertheless, the circular economy agenda on sustainable and responsible consumption and production reminds professionals and educators that the ESG knowledge-practice gap must be filled effectively with stakeholders in mind, whether ESG investors or carbon neutrality regulators.

This study has some limitations, such as the lack of a comprehensive Chinese-language ESG review and the limited geographic and disciplinary representation. Nevertheless, it has succinctly visualized both the overall and detailed picture from the high-level organizational actions to meso-level capabilities based on stakeholder analysis and state-of-art ESG research and practices gathered through design workshops. Future work is needed to verify and validate the requirements and framework by considering cultural and regional factors. Further, future work is needed to advance the structure and content of ESG education and training with an integrated understanding of what enterprises and their stakeholders need to innovate, with ESG and carbon information as core green digital transformation activities.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

Conceptualization, H-TL, and C-LP; methodology, H-TL and C-LP; software, H-TL and C-LP; data curation, H-TL, and C-LP; writing—review and editing, H-TL, C-LP, and YZ; visualization, H-TL and C-LP; funding acquisition, YZ and H-TL. All authors have read and agreed to the published version of the manuscript YZ.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher’s note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2023.1119011/full#supplementary-material

References

Albastroiu Nastase, I., Negrutiu, C., Felea, M., Acatrinei, C., Cepoi, A., and Istrate, A. (2022). Toward a circular economy in the toy industry: The business model of a Romanian company. *Sustainability* 14, 22. doi:10.3390/su14010022

Archer, M. (2019). "Sustainable finance," in *Oxford bibliographies: Environmental science*. Editor E. Wohl (Oxford, UK: Oxford University Press). doi:10.1093/OBO/9780199363445-0117

Bertella, G., Lupini, S., Rossi Romanelli, C., and Font, X. (2021). Workshop methodology design: Innovation-oriented participatory processes for sustainability. *Ann. Tour. Res.* 89, 103251. doi:10.1016/j.annals.2021.103251

Bradley, B. (2021). *ESG investing for dummies*. 1st ed. Indianapolis: John Wiley & Sons.

Brecht, P., Niever, M., Kerres, R., Ströbele, A., and Hahn, C. H. (2021). Smart platform experiment cycle (SPEC): A process to design, analyze, and validate digital platforms. *AIEDAM* 35, 209–225. doi:10.1017/S0890060421000081

H. Bril, G. Kell, and A. Rasche (Editors) (2023). *Sustainability, technology and finance: Rethinking how markets integrate ESG* (Milton Park, Abingdon, Oxon ; New York, NY: Routledge).

Buehring, J., and Bishop, P. C. (2020). Foresight and design: New support for strategic decision making. *She Ji: J. Des. Econ. Innovation* 6, 408–432. doi:10.1016/j.sheji.2020.07.002

Bunce, L., Baird, A., and Jones, S. E. (2017). The student-as-consumer approach in higher education and its effects on academic performance. *Stud. High. Educ.* 42, 1958–1978. doi:10.1080/03075079.2015.1127908

P. Câmara and F. Morais (Editors) (2022). *The Palgrave handbook of ESG and corporate governance* (Cham, Switzerland: Palgrave Macmillan). doi:10.1007/978-3-030-99468-6

CEADs (2022). *CEADs (carbon emission accounts and Datasets for emerging economies)*. CEADs Offcial Website. Available at: https://www.ceads.net/ (Accessed October 27, 2021).

Chan, Y., Hogan, K., Schwaiger, K., and Ang, A. (2020). ESG in factors. *J. Impact ESG Invest. Fall* 1, 26–45. doi:10.3905/jesg.2020.1.1.026

Chan, Y. K., and Hsieh, M. Y. (2022). An empirical study on higher education C-ESG sustainable development strategy in lower-birth-rate era. *Sustainability* 14, 12629. doi:10.3390/su141912629

Circulab (2020). *The Partner Map: Create shared value with your stakeholders*. Paris, France: Circulab: Design for Regeneration. Available at: https://circulab.com/toolbox-circular-economy/partner-map-cooperation/ (Accessed November 29, 2021).

Cooperman, E. S. (2018). Corporations to the rescue: A New stakeholder paradigm? An overview for US corporations & financial institutions. *Int. Rev. Account. Bank. Finance* 10.

Daou, A., Mallat, C., Chammas, G., Cerantola, N., Kayed, S., and Saliba, N. A. (2020). The Ecocanvas as a business model canvas for a circular economy. *J. Clean. Prod.* 258, 120938. doi:10.1016/j.jclepro.2020.120938

Dargusch, P. (2017). China must lead on emissions trading. *Science* 357, 1106–1107. doi:10.1126/science.aap7960

Dathe, T., Dathe, R., Dathe, I., and Helmold, M. (2022). *Corporate social responsibility (CSR), sustainability and environmental social governance (ESG): Approaches to ethical management*. Berlin, Germany: Springer. Available at: http://gen.lib.rus.ec/book/index.php?md5=1611C920B3B47C5AE587995FE30CCF29 (Accessed February 16, 2023).

Dautenhahn, K. (2022). "Human-robot interaction," in *The encyclopedia of human-computer interaction*. Available at: https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/human-robot-interaction (Accessed December 4, 2022).

U. Demiray and S. Sever (Editors) (2011). "From consumer to prodsumer: Contemplation on product, producer and consumer in tertiary education," *Marketing online education programs: Frameworks for promotion and communication*. *Advances in educational marketing, administration, and leadership* (Hershey, Pennsylvania, USA: IGI Global). doi:10.4018/978-1-60960-074-7

Dieguez, T., Ferreira, L. P., Silva, F. J. G., and Tjahjono, B. (2020). Open innovation and sustainable development through industry-academia collaboration: A case study of automotive sector. *Procedia Manuf.* 51, 1773–1778. doi:10.1016/j.promfg.2020.10.246

DiNapoli, J. (2021). *PwC planning to hire 100,000 over five years in major ESG push*. London: Reuters. Available at: https://www.reuters.com/business/sustainable-business/pwc-planning-hire-100000-over-five-years-major-esg-push-2021-06-15/ (Accessed November 29, 2021).

Dmuchowski, P., Dmuchowski, W., Baczewska-Dabrowska, A. H., and Gworek, B. (2023). Environmental, social, and governance (ESG) model; impacts and sustainable investment-Global trends and Poland's perspective. *J. Environ. Manage.* 329, 117023. doi:10.1016/j.jenvman.2022.117023

Dwivedi, Y. K., Hughes, L., Kar, A. K., Baabdullah, A. M., Grover, P., Abbas, R., et al. (2022). Climate change and COP26: Are digital technologies and information management part of the problem or the solution? An editorial reflection and call to action. *Int. J. Inf. Manag.* 63, 102456. doi:10.1016/j.ijinfomgt.2021.102456

Eisape, D. A. (2022). Transforming pipelines into digital platforms: An illustrative case study transforming a traditional pipeline business model in the standardization industry into a digital platform. *J. Open Innovation: Technol. Mark. Complex.* 8, 183. doi:10.3390/joitmc8040183

Ernst & Young (2022). *Supply chain and operations*. Available at: https://www.ey.com/zh_cn/consulting/supply-chain-operations (Accessed December 6, 2022).

D. C. Esty and T. Cort (Editors) (2020). *Values at work: Sustainable investing and ESG reporting* (Cham, Switzerland: Palgrave Macmillan). doi:10.1007/978-3-030-55613-6

Fang, M., Nie, H., and Shen, X. (2023). Can enterprise digitization improve ESG performance? *Econ. Model.* 118, 106101. doi:10.1016/j.econmod.2022.106101

Fatima, S., Desouza, K. C., Buck, C., and Fielt, E. (2022). Public AI canvas for AI-enabled public value: A design science approach. *Gov. Inf. Q.* 39, 101722. doi:10.1016/j.giq.2022.101722

Gao, P., Yue, S., and Chen, H. (2021). Carbon emission efficiency of China's industry sectors: From the perspective of embodied carbon emissions. *J. Clean. Prod.* 283, 124655. doi:10.1016/j.jclepro.2020.124655

Hevner, A. R., March, S. T., Park, J., and Ram, S. (2004). Design science in information systems research. *MIS Q.* 28, 75–105. doi:10.2307/25148625

Hofmann, F., Marwede, M., Nissen, N. F., and Lang, K. D. (2017). "Circular added value: Business model design in the circular economy," in *PLATE: Product lifetimes and the environment*, 171–177. doi:10.3233/978-1-61499-820-4-171

Hynes, M. (2017). Students-as-producers: Developing valuable student-centered research and learning opportunities. *Int. J. Res. Stud. Educ.* 7. doi:10.5861/ijrse.2017.1858

Internet Society of China (2022). *Open requests for comments on "carbon Peak carbon neutral management and service platform – Part 1: Specification of architecture" association standard*. Beijing, China: Internet Society of China - Announcement. Available at: https://www.isc.org.cn/article/14821409542631424.html (Accessed December 24, 2022).

ITU-T (2020). *L.1470: Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement*. Geneva: ITU-T Study Group 5. Available at: https://handle.itu.int/11.1002/1000/14084 (Accessed December 1, 2022).

ITU-T (2022). *L.1480: Enabling the Net Zero transition: Assessing how the use of information and communication technology solutions impact greenhouse gas emissions of other sectors*. Geneva: ITU-T Study Group 5. Available at: https://www.itu.int/rec/T-REC-L.1480-202212-I (Accessed December 1, 2022).

Johnson, M. (2022). *ITU at COP27: Standards for green digital transformation*. Geneva, Switzerland: International Telecommunication Union (ITU) Hub. Available at: https://www.itu.int/hub/2022/11/itu-cop27-standards-sustainable-digital-transformation/ (Accessed December 1, 2022).

Lagrasta, F. P., Pontrandolfo, P., and Scozzi, B. (2021). Circular economy business models for the Tanzanian coffee sector: A teaching case study. *Sustainability* 13, 13931. doi:10.3390/su132413931

Lauten-Weiss, J., and Ramesohl, S. (2021). The circular business framework for building, developing and steering businesses in the circular economy. *Sustainability* 13, 963. doi:10.3390/su13020963

Liao, H. T., and Huang, W. Y. (2021). "Marketing technologies in the agri-food industry: A scoping review of digital technologies for social and ecological sustainability," in 2021 IEEE 21st International Conference on Communication Technology (Tianjin, China: IEEE). doi:10.1109/ICCT52962.2021.9657939

Liao, H. T., Huang, W. Y., Zhou, X., Pan, C. L., Zhang, Y., and Liu, H. (2021). "A research and education agenda based on a bibliometric analysis of CSR and ESG reporting," in 2021 IEEE 2nd International Conference on Technology, Engineering, Management for Societal Impact using Marketing, Entrepreneurship and Talent, TEMSMET 2021 (Pune, India: IEEE), 1–7. doi:10.1109/TEMSMET53515.2021.9768775

Liao, H. T., and Pan, C. L. (2021). "The role of resilience and human rights in the green and digital transformation of supply chain," in 2021 IEEE 2nd International Conference on Technology, Engineering, Management for Societal Impact using Marketing, Entrepreneurship and Talent, TEMSMET 2021 (Pune, India: IEEE), 1–7. doi:10.1109/TEMSMET53515.2021.9768730

Liu, H., and Liao, H. T. (2021). "From the word-of-mouth to social impact: A bibliometric analysis of social media marketing," in 2021 IEEE 2nd International Conference on Technology, Engineering, Management for Societal Impact using Marketing, Entrepreneurship and Talent, TEMSMET 2021 (Pune, India: IEEE), 1–6. doi:10.1109/TEMSMET53515.2021.9768747

March, S. T., and Smith, G. F. (1995). Design and natural science research on information technology. *Decis. Support Syst.* 15, 251–266. doi:10.1016/0167-9236(94)00041-2

Meunier, L., and Ohadi, S. (2022). Misconceptions about socially responsible investments. *J. Clean. Prod.* 373, 133868. doi:10.1016/j.jclepro.2022.133868

Normile, D. (2020). Can China, the world's biggest coal consumer, become carbon neutral by 2060? *Science*. Available at: https://www.science.org/content/article/can-china-worlds-bigger-coal-consumer-become-carbon-neutral-2060 (Accessed November 29, 2021).

Oldford, E., Willcott, N., and Kennie, T. (2022). Can student managed investment funds (SMIFs) narrow the environmental, social and governance (ESG) skills gap? *Manag. Financ.* 48, 57–77. doi:10.1108/MF-07-2021-0317

Plaskova, N. S. (2022). The impact of ESG principles on corporate reporting. *Account. Healthc.* 2022, 26–35. doi:10.33920/med-17-2211-03

PR Newswire APAC (2021). *PR Newswire launches inaugural ESG communications handbook in APAC*. Hong Kong: PR Newswire APAC. Available at: https://en.prnasia.com/story/338484-0.shtml (Accessed December 5, 2022).

PricewaterhouseCoopers (2022). *ESG Reporting Tool: Streamline and automate the reporting of ESG information*. London, UK: PwC Store. Available at: https://store.pwc.in/en/products/esg-reporting-tool (Accessed December 5, 2022).

PwC (2022). *Asset and wealth management revolution 2022: Exponential expectations for ESG*. London, UK: PwC (PricewaterhouseCoopers). Available at: http://www.pwc.com/awm-revolution-2022 (Accessed December 4, 2022).

PwC China; UNDP; CCOIC (2020). *Private sector awareness of the sustainable development goals*. Beijing: PwC (PricewaterhouseCoopers) China; United Nations Development Programme (UNDP); the China Chamber of International Commerce (CCOIC). Available at: https://www.pwccn.com/en/services/consulting/publications/private-sector-awareness-of-the-sustainable-development-goals-jul2020.html (Accessed December 4, 2022).

Roy, S. K., Balaji, M. S., Sadeque, S., Nguyen, B., and Melewar, T. C. (2017). Constituents and consequences of smart customer experience in retailing. *Technol. Forecast. Soc. Chang.* 124, 257–270. doi:10.1016/j.techfore.2016.09.022

Salvador, R., Barros, M. V., Freire, F., Halog, A., Piekarski, C. M., and De Francisco, A. C. (2021). Circular economy strategies on business modelling: Identifying the greatest influences. *J. Clean. Prod.* 299, 126918. doi:10.1016/j.jclepro.2021.126918

Sheehan, N. T., Fox, K. A., Klassen, M., and Vaidyanathan, G. (2022). Threshold concepts and ESG performance: Teaching accounting students reconceptualized fundamentals to drive future ESG advocacy. *Acc. Educ.* 2022, 1–25. Latest Articles. doi:10.1080/09639284.2022.2122727

Shmatov, C., and Castelli, C. R. (2023). *Quantitative methods for ESG finance*. Hoboken, New Jersey: Wiley.

Simon, A., and Kumar, V. (2001). Clients' views on strategic capabilities which lead to management consulting success. *Manag. Decis.* 39, 362–372. doi:10.1108/EUM0000000005472

Swanson, E. B. (2010). Consultancies and capabilities in innovating with IT. *J. Strategic Inf. Syst.* 19, 17–27. doi:10.1016/j.jsis.2009.12.001

Tang, F. (2021). *China's carbon-neutrality plans now falls under purview of central bank*. Hong Kong: South China Morning Post. Available at: https://www.scmp.com/economy/china-economy/article/3129881/chinas-carbon-neutrality-plans-now-hands-central-bank-which (Accessed December 4, 2022).

Trefz, N. M. (2023). *Stock price dynamics of US REITs: The effect of short selling, covid-19, and ESG*. 1st ed. Wiesbaden, Germany: Springer Gabler. Available at: http://gen.lib.rus.ec/book/index.php?md5=A28D735C4B24ACD5F6B11C8AC6979A86 (Accessed February 16, 2023).

UNESCO (2020). *Education for sustainable development: A roadmap*. Paris, France: UNESCO United Nations Educational, Scientific and Cultural Organization. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000374802.locale=en (Accessed December 4, 2022).

United Nations (2020). *Secretary-General's roadmap for digital cooperation*. New York, NY, USA: United Nations. Available at: https://www.un.org/en/content/digital-cooperation-roadmap/ (Accessed October 31, 2021).

Uyar, A., Karaman, A. S., and Kilic, M. (2020). Is corporate social responsibility reporting a tool of signaling or greenwashing? Evidence from the worldwide logistics sector. *J. Clean. Prod.* 253, 119997. doi:10.1016/j.jclepro.2020.119997

Wang, C., and Wang, F. (2017). China can lead on climate change. *Science* 357, 764. doi:10.1126/science.aao2785

Worthington-Smith, M. D., and Giamporcaro, S. (2021). "ESG materiality: Insights from the South African investment industry," in *Advances in finance, accounting, and economics*. Editor I. Y. Gok (Hershey, Pennsylvania, USA: IGI Global), 217–240. doi:10.4018/978-1-7998-8501-6.ch011

Xinhua (2021). *Action plan for carbon Dioxide peaking before 2030*. Beijing: The State Council, The People's Republic of China. Available at: https://english.www.gov.cn/policies/latestreleases/202110/27/content_WS6178a47ec6d0df57f98e3dfb.html (Accessed November 29, 2021).

Yu, E. P., Luu, B. V., and Chen, C. H. (2020). Greenwashing in environmental, social and governance disclosures. *Res. Int. Bus. Financ.* 52, 101192. doi:10.1016/j.ribaf.2020.101192

Zhang, Y., Pan, C.-L., and Liao, H.-T. (2021). Carbon neutrality policies and technologies: A scientometric analysis of social science disciplines. *Front. Environ. Sci.* 9. doi:10.3389/fenvs.2021.761736

Zhou, X., Pan, C. L., Feng, Y., and Bu, M. (2021). "Smart customer experience of ESG education capability building roadmap for smart consulting, reporting and communicating for carbon Peak and carbon neutrality goals," in 2021 3rd International Conference on Internet Technology and Educational Informization (ITEI) (Guangzhou, China: IEEE), 333–336. doi:10.1109/ITEI55021.2021.00083