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Co-design capacity development for the UN Ocean Decade

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Effective ocean governance plays a critical role in managing and coordinating human activities, policies, and institutions to ensure the sustainable use and conservation of marine resources. Recognizing the importance of effective ocean governance, there is a growing awareness that new research approaches are needed to bring together actors from academia and non-academic sectors. Together they need to develop transformative science solutions for a more inclusive and equitable ocean governance system. Despite widespread interest in this collaborative endeavor, limited resources are available to provide structured support and training. This creates a pressing need to develop capacity and promote a shared understanding of collaborative research methodologies, such as co-design. In response to the need for capacity development in such methodologies, the "Co-design for the Ocean Decade" online training course was launched in collaboration with IOC-UNESCO in 2022, starting with a first pilot course in the African region. This first co-design training course under the Ocean Decade framework serves as a practical and research-backed model for future co-design training programs in other regions. The evaluation results of the course reveal its effectiveness in enhancing participants' knowledge and skills in key co-design areas, particularly in communication with stakeholders. The evaluation also highlights areas for improvement, such as the need for (i) monitoring and evaluation, and (ii) follow-up opportunities for practice and funding support. Based on the evaluation, for future research and training programs, we recommend: (1) to incorporate local and regional context into the training, (2) to integrate co-design training into ocean science education, and (3) to embed co-design of research and training into the capacity development program of the Ocean Decade.

KEYWORDS

capacity development, co-design, knowledge co-production, stakeholder engagement, transformative ocean science, ocean governance

1 Introduction

The ocean plays a critical role in maintaining the health of the planet and the wellbeing of humans by providing fundamental ecosystem services, such as regulating climate, protecting coastal communities, maintaining biodiversity, and providing food, medicine, and other resources (Barbier, 2017; Visbeck, 2018). The ocean also provides a vast array of economic benefits, including fishing, shipping, tourism, and energy production. A study estimated that the size of the global ocean economy was US$ 1.5 trillion in 2010, and was projected to increase to US$ 3.0 trillion in 2030 (OECD, 2016; Sumaila et al., 2021). An even higher estimate puts annual ecosystem services from Coral Reefs alone at close to US$ 10 trillion (Costanza et al., 2014). However, the continued degradation of

the ocean due to climate change (Harley et al., 2006; Oliver-Smith, 2009; Hoegh-Guldberg and Bruno, 2010; Poloczanska et al., 2013; Gattuso et al., 2015; Pörtner et al., 2019), pollution (Clark et al., 2001), and overfishing (Pauly et al., 1998; Coll et al., 2008; Watson et al., 2013; McCauley et al., 2015) could significantly reduce its economic value, as well as other ecosystem services over time. The United Nations Decade of Ocean Science for Sustainable Development (2021–2030), hereby called "Ocean Decade" in short, addresses the 10 most pressing challenges faced by the ocean, each of which has complex social-ecological characteristics (Ryabinin et al., 2019).

Effective governance is crucial for addressing these complex challenges faced by the ocean (Chang, 2010; Pinsky et al., 2018; Werle et al., 2019; Borja, 2023). Ocean governance involves the management and coordination of human activities to ensure the sustainable use and conservation of marine resources. It encompasses a range of actors, policies, and institutions at local, regional, and global levels. The integration of diverse stakeholders (rights-holders) including scientists, policymakers, industry representatives, and civil society, is essential for enhancing ocean governance and achieving sustainable outcomes (Brodie Rudolph et al., 2020; Haas et al., 2021; Cao and Chang, 2023). To support and enable more effective ocean governance, new research models and transformative knowledge production methods are needed. These methods range from varied forms of participatory research, through knowledge co-production, to transdisciplinary (TD) research. Each term represents increasing levels of stakeholder engagement in the research process, moving from participatory research, where stakeholders may contribute insights or feedback (Mackinson et al., 2011; Avilés Irahola et al., 2022), to knowledge co-production (Norström et al., 2020; Cazé et al., 2022; Jidda-Fada and Bennett, 2022), which entails a more equal partnership between researchers and stakeholders, and is culminating in transdisciplinary research. This most integrated form not only bridges academic disciplines, but also deeply involves all stakeholders in the research process from conception to execution (Steger et al., 2021; Franke et al., 2022; Klein, 2022; Archibald et al., 2023; Reed et al., 2023; Descalzi et al., 2024). These distinctions align with Arnstein's "ladder of participation," highlighting the depth and breadth of engagement critical for addressing complex ocean governance challenges (Arnstein, 1969). The transformative ocean science promoted by the Ocean Decade is one such approach that aims to provide a more comprehensive and integrated understanding of the ocean and the human activities that impact it through transdisciplinary and participatory research collaborations (Pearlman et al., 2021).

Co-design of research is a key aspect of transformative ocean science, as it promotes collaboration and integration among different stakeholder groups, and is essential for developing a comprehensive understanding of the ocean and finding solutions (IOC-UNESCO, 2021; Cazé et al., 2022). Co-design of research here refers to the process of jointly designing a research project. However, there are still barriers to implementing and supporting co-design, including the lack of personal, financial, technical, and institutional capacity. Marine science curricula rarely include the necessary skills to equip researchers for engaging in co-design (Rölfer et al., 2022). Training programs are necessary to equip ocean communities, including researchers, practitioners and policy-makers, with the skills and knowledge needed to work in a transdisciplinary manner (Hillebrandt-Andrade et al., 2021; IOC-UNESCO, 2021; Satterthwaite et al., 2022).

Despite the growing demand such collaborative transdisciplinary training programs are still in the early stages of development (Satterthwaite et al., 2022). This is due in part to the fact that transdisciplinary approaches to ocean science and management are still relatively new and challenging to implement (Celliers et al., 2021). They require close collaboration and communication among experts from multiple disciplines, as well as a willingness to challenge traditional disciplinary boundaries (Yates et al., 2015; Franke et al., 2022). The complex nature of the ocean and the distinct challenges of progressing toward ocean sustainability also require training programs that are different from those generally found in the sustainability science field (Begossi, 2008; Franke et al., 2022).

To address this gap, we developed and implemented the "Co-design for the Ocean Decade" online training course in 2022, funded by and in collaboration with the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and with the first piloting course focused on the African region. The goals of this training course were (i) to strengthen core co-design competencies of participants, (ii) to prepare them for advancing solutions to real-world sustainability problems, and (iii) to begin constructing co-designed project proposals for endorsement as Decade Actions.[1]

This study aims to provide valuable insights into co-design training by explaining the concept and by summarizing and evaluating the learning experience. First, we introduce relevant theories in co-design research, which were applied to create informative and engaging training materials. Next, the training concept, format and materials will be explained, followed by a detailed evaluation of the course and the participants' experience. Finally, based on the evaluation results, we explore ways to integrate training feedback into future co-design of research, enhance capacity development, and contribute to more effective ocean governance within the context of the Ocean Decade.

2 Theoretical background

The incorporation of theoretical components is pivotal in crafting a comprehensive training course that is both informative and impactful. Here we present the theoretical aspects of co-design that were integrated into the training program. By conducting a thorough examination of relevant theories, we can gain an in-depth understanding of the topics covered in the training course, including proven techniques and approaches. This knowledge constituted the foundation for the development of training materials that are engaging and educational for participants. By embedding theories into the training modules, we aim to provide a robust foundation for the subjects taught while making them more practical and relevant by linking to real-world scenarios.

1 Required documentation for the submission of a Decade Action can be found on the Global Stakeholder Forum: https://forum.oceandecade.org/.

2.1 What is co-design?

Co-design is a multifaceted concept within academia. It is normally used as an umbrella term that covers a wide range of different practices with varied historical roots (Hakkarainen et al., 2021). At the most foundational level, co-design means people collaborate and contribute their individual resources, knowledge, and skills to jointly develop ideas and circumstances that contribute to a better future (Zamenopoulos and Alexiou, 2018). In the environmental management field, co-design refers to the initial phase of a knowledge co-production process in transdisciplinary research (Lang et al., 2012), in which "researchers and nonacademic partners jointly develop a research project and define research questions that meet their collective interests and needs" (Moser, 2016, p. 108).

Accordingly, in the context of the Ocean Decade, we understand co-design as a collaborative process that brings together researchers and non-academics from different sectors to address ocean-related challenges. This process involves (i) identifying and describing a real-world ocean-related problem, (ii) defining common research goals that are both scientifically and socially relevant, (iii) designing a framework for knowledge integration, and (v) building a collaborative research team. By including marginalized and disadvantaged individuals and groups, co-design seeks to increase trust, improve the relevance of research outcomes, and enhance support for ocean-related initiatives.

A challenge in co-design is to identify and engage all relevant stakeholders, ensuring that their views are reflected in the project idea. This helps to create a basis for collaboration that is built on shared responsibility and ownership, and to increase the chances of the research being useful to all parties, fitting the local context and responding to real needs (Lam et al., 2020).

2.2 What are the key elements in co-design?

The empirical evidence demonstrates the lack of a standard approach to co-designing research projects due to differences in capacities among those involved and the varying topics, actors, and purposes (Asah and Blahna, 2020; Robert et al., 2022). Therefore, it is crucial to identify the key elements critical to co-design. In this context, we utilize the co-design guidance compiled by Ferse et al. (2021) as a starting point. It provides a comprehensive set of elements and objectives that can help ensure a successful co-design phase and is structured into four parts (Figure 1):

The co-design phase begins with a collaborative development of a research project that is based on a shared vision and common agenda (Part 1). It is important to involve stakeholders early on and to take into account the "who" and "how" throughout the various project stages, including co-design, implementation, co-production, and co-dissemination of results (Part 2). The co-design phase provides an opportunity to establish and strengthen equal partnerships through effective project management and communication within the team (Part 3). To ensure the longevity of the project impact, it is crucial to address the sustainability of project activities and outcomes during the co-design phase (Part 4). While these four parts are distinct, they are not sequential and are instead interrelated and can be conducted simultaneously.

2.3 What are the key competencies in co-design?

This section identifies the key competencies needed for individuals to effectively co-design a research project. By competencies, we mean "a functionally linked complex of knowledge, skills, and attitudes that enable successful task performance and problem-solving" (Wiek et al., 2011, p. 204). The identified competency areas will serve as the foundation for creating customized training programs and methods. These competency fields outline what participants are expected to achieve by the end of the training course, as described in the following sections.

The field of sustainability science has identified various key competencies essential for professionals and researchers in addressing complex problems. These competencies include systems-thinking, anticipatory, normative, strategic and interpersonal competence, and integrated problem-solving (Wiek et al., 2011, 2016; Lozano et al., 2017; Leicht et al., 2018; Evans, 2019). These competencies distinguish sustainability professionals as "systemic problem solvers, change agents, and transition managers" (Wiek et al., 2016).

However, the literature on competencies specifically related to co-design or transdisciplinary research is limited. Kemp and Nurius (2015) argued that effective participation in TD research calls for the ability to conduct research to navigate and integrate diverse methodological and theoretical frameworks, and sophisticated communication and collaborative skills. Pearce et al. (2018) introduced "Competence Fields" for "The Transdisciplinarity Lab" courses, namely communicating values, reflecting about self and others, applying concepts in the real world, framing complex problems with others, researching in and with the real world, and imaging solutions and their consequences. Moore et al. (2018) highlighted the importance of skills for conducting TD research, including scholarly paper writing, obtaining grant funding, expansive thinking, learning how to translate research and increase the impact of one's work, and teamwork skills, including navigating differences, tensions or conflict on teams, and good communication skills.

While these lists exhibit certain differences, they also coincide in terms of a number of key competencies for conducting co-design. For instance, there is general agreement that effective communication and teamwork/collaborative skill sets are of particular importance for co-designing and co-implementing a project. Thus, drawing on these authors' work, and with special emphasis on the co-design phase of knowledge co-production, we highlight the following relevant competencies that help participants frame the project designing part (Figure 2):

- Communication and collaboration competency: the ability to use common language to explain complex problems, mediate between academic and Indigenous, local and practical

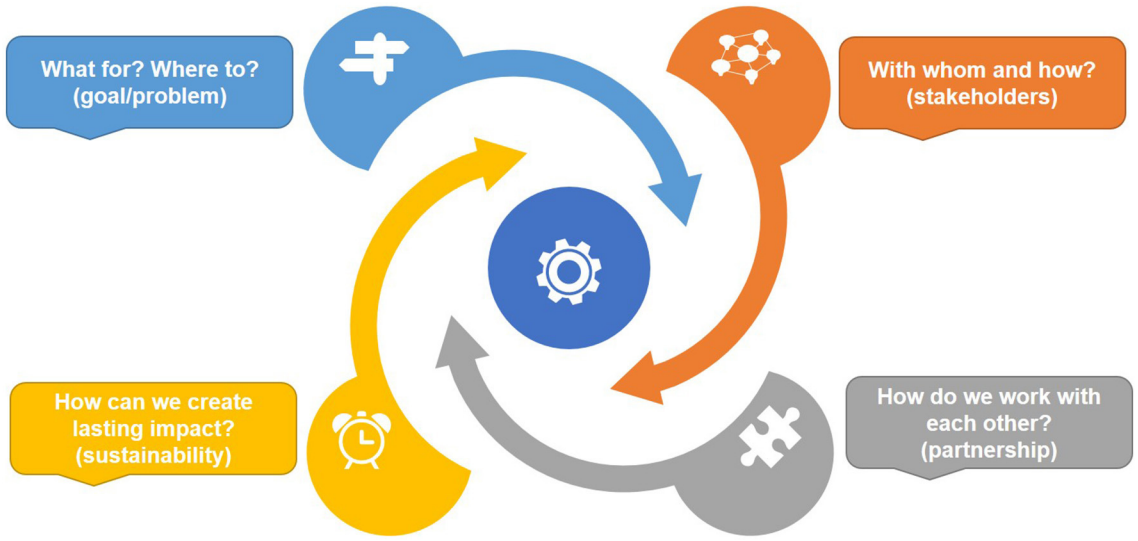

FIGURE 1
Key elements in co-design. Adapted from Ferse et al. (2021).

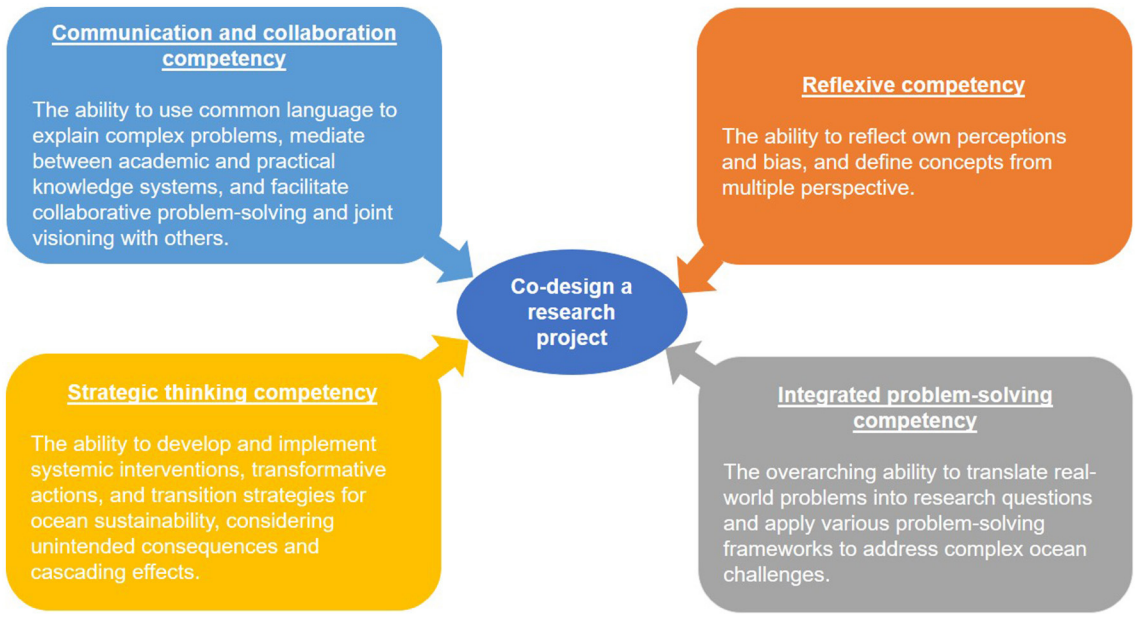

FIGURE 2
Key competencies for co-design.

knowledge systems, and facilitate collaborative problem-solving and joint visioning with others.

- Reflexive competency: the ability to reflect on personal biases and perspectives and consider concepts from multiple angles, including critical thinking and self-reflection, and to question existing concepts and processes.
- Strategic thinking competency: the ability to develop and implement systemic interventions, transformative actions, and transition strategies for ocean sustainability, considering unintended consequences and cascading effects, and to coordinate stakeholders to overcome barriers to achieve envisioned outcomes.
- Integrated problem-solving competency: the overarching ability to translate real-world problems into research questions and apply various problem-solving frameworks to address complex ocean challenges, leading to the development of inclusive and equitable solutions for ocean sustainability.

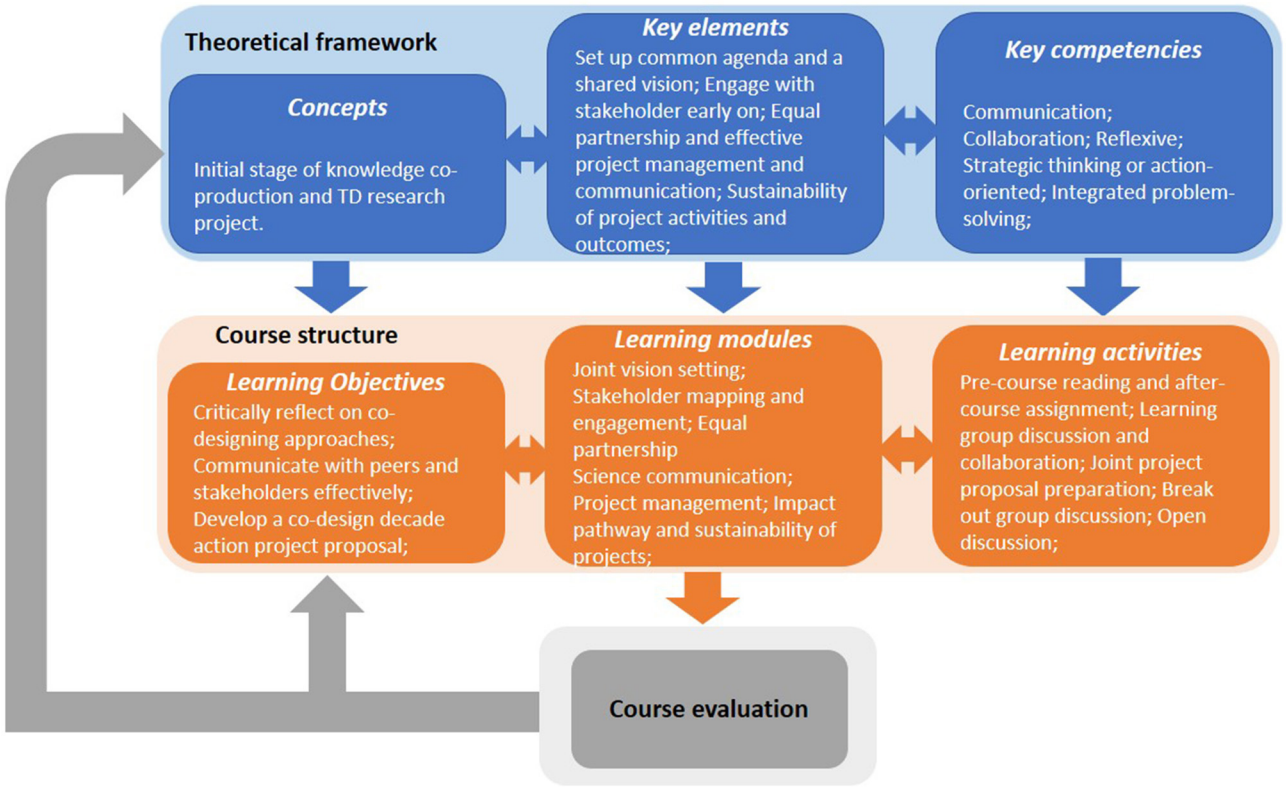

FIGURE 3
Iterative training model.

3 Course rationale and learning modules

3.1 Iterative training model

The course was designed using an iterative model, which involved several learning themes that are related to strengthening core competencies. The learning themes consisted of tailored activities and robust evaluation techniques that help measure the effectiveness of the course and its impact on the participants' knowledge and skills. As indicated in Figure 3, the course structure (orange) was informed by the key elements for co-designing research and core competencies discussed in the previous section (blue). Key co-design research elements formed the learning modules, while core competences influenced the selection of learning activities, as well as setting up specific course objectives.

The learning objectives, modules, and activities serve as the foundation for the evaluation methods (gray). The evaluation is critical to determine the effectiveness of the training course and to identify the areas that need to be improved, enabling the design and content of future training modules and activities to be adjusted accordingly. This includes enhancing the effectiveness of activities and improving overall satisfaction. In addition to improving future training, the evaluation of the training course plays a crucial role in shaping the direction and content of future co-designed research, ensuring that it is relevant to practical needs and delivering the desired outcomes.

In this training course design, we followed a systematic five-step process:

- Step 1—Framework Development: we developed a course framework that included training objectives, modules, and activities (explained in detail in Section 3.2). This framework served as a master plan and an important guide for both lecturers and participants, ensuring a shared understanding and agreement on the intended outcomes of the training course.
- Step 2—Participant Identification and Needs Assessment: we assessed the background, learning preferences, and goals of participants through a thorough analysis of their motivation letters and a pre-course survey. This information helped us to determine the specific training needs of participants and whether they have enough in common to form one group, or if multiple groups should be formed based on shared characteristics.
- Step 3—Detailed Course Planning and Development: based on the framework, we prepared a weekly course agenda and materials, and identified a team of 14 lecturers with complementary styles, skills, and knowledge. We ensured gender equality and balanced regional and international expertise when selecting the lecturers. Additionally, we formed six learning groups based on participants' interests to serve as learning and collaboration hubs throughout the course.

- Step 4—Delivery: the 6-week course was delivered online via the Zoom platform and integrated with interactive discussion tools such as Miro, Mural, and Google Jamboard. The course took place from November 28, 2022, to January 23, 2023, with a 3-week holiday break in between. At the end of the course, evaluation data were collected through a survey and course observation.
- Step 5—Refinement: the results of the evaluation were analyzed and used to inform the design and content of future training modules and activities. This step ensured that the course will be relevant and effective for future participants.

3.2 Learning objectives, modules and activities

The training course included the following modules: joint vision setting, stakeholder mapping and engagement, project management and science communication, equal partnership, impact pathway, and sustainability of the project. A more detailed description of the course curriculum can be found in Supplementary Appendix A. The objective of this course was to help ocean communities in Africa develop competencies critical to the success of co-design. This kind of competency-oriented thinking can provide a helpful model for mapping where and how to incorporate transferable skills and competencies into the learning modules, such as project management and stakeholder engagement.

The specific learning objectives were set up to maximize course effectiveness. Upon completion of the course, the participants were expected to have obtained the ability to:

- Critically reflect on theoretical and methodological approaches of co-design as ways of bridging the knowledge-action gap (reflexive competence, creative, and strategic competency);
- Communicate with peers and stakeholders in intercultural settings (interpersonal and communication competence, collaboration competence);
- Develop a co-designed Ocean Decade action project proposal that is ready to be submitted for endorsement as Ocean Decade Action (integrated problem-solving competency, creative, and strategic competency).

Key Besides presentations by the lecturers, key training activities included (i) learning group collaboration and discussion, (ii) joint Ocean Decade Action proposal preparation, (iii) pre-and post-course assignments, (iv) break-out group discussion, and (v) open discussion. Each session ended with a half-hour summary of the key findings and linking these findings to the training objectives and to other sessions.

In terms of peer learning and case studies, six learning groups were formed based on the participants' needs: ocean pollution, ocean literacy and knowledge for all, ocean digital tools and observation, sustainable fishery and blue economy, climate change and coastal resilience, and biodiversity conservation and community engagement. Joint Ocean Decade Action proposals were developed by each learning group and presented on the last day of the course. These proposals emphasized the connection to co-design and training objectives, and received timely feedback from invited experts.

4 The evaluation of the course

The primary objective of the evaluation was to measure the effectiveness of the training modules and methods. To achieve this, we considered a range of metrics that reflected both the quality of the training experience and its impact on participants' knowledge and skills. Specifically, we looked at the following indicators:

- Training outcomes: this involved measuring changes in participants' knowledge and skills in co-design of research. We measured this by assessing changes in their co-design knowledge and skills (quantitative) and combined this with open-ended questions.
- Engagement levels: this referred to the degree of involvement and interaction that participants had with the learning activity. We measured engagement through the activity levels of learning groups and the number of co-designed proposals developed during the course.

- Overall completion and satisfaction rates: this referred to the percentage of participants who completed the training course by actively attending at least four out of six training sessions. Satisfaction was measured by asking participants to rate the course or activity in terms of usefulness, relevance, and overall satisfaction.

4.1 Participants' profile

Forty-one participants from 15 African and adjacent island countries were selected from a pool of 119 applicants to take part in the training course (Figure 4). The gender distribution was fairly even, with 21 women and 20 men participating. The majority, 26 participants, were employed as researchers at research institutes or universities (63%). Nine (22%) participants worked as practitioners in NGOs, and six (15%) participants were involved in policy-making in local or national government authorities. It is worth mentioning that seven participants (17%) worked at the intersection of research and policy, or of research and practice, which partially explains their motivation for joining the training course. Most participants were still in the early stages of their careers, with 31 (76%) having <10 years of working experience after obtaining their highest degree. Additionally, 39 (95%) participants used English professionally.

The selection criteria included having adequate knowledge in marine or ocean science, leading to a majority of participants coming from related professional backgrounds. However, their disciplines ranged from physical oceanography to marine biology, fisheries, marine social science, governance, and marine meteorology, providing a diverse range of backgrounds and challenges for course communication, but also offering opportunities to improve interdisciplinary communication skills and foster collaboration across disciplines.

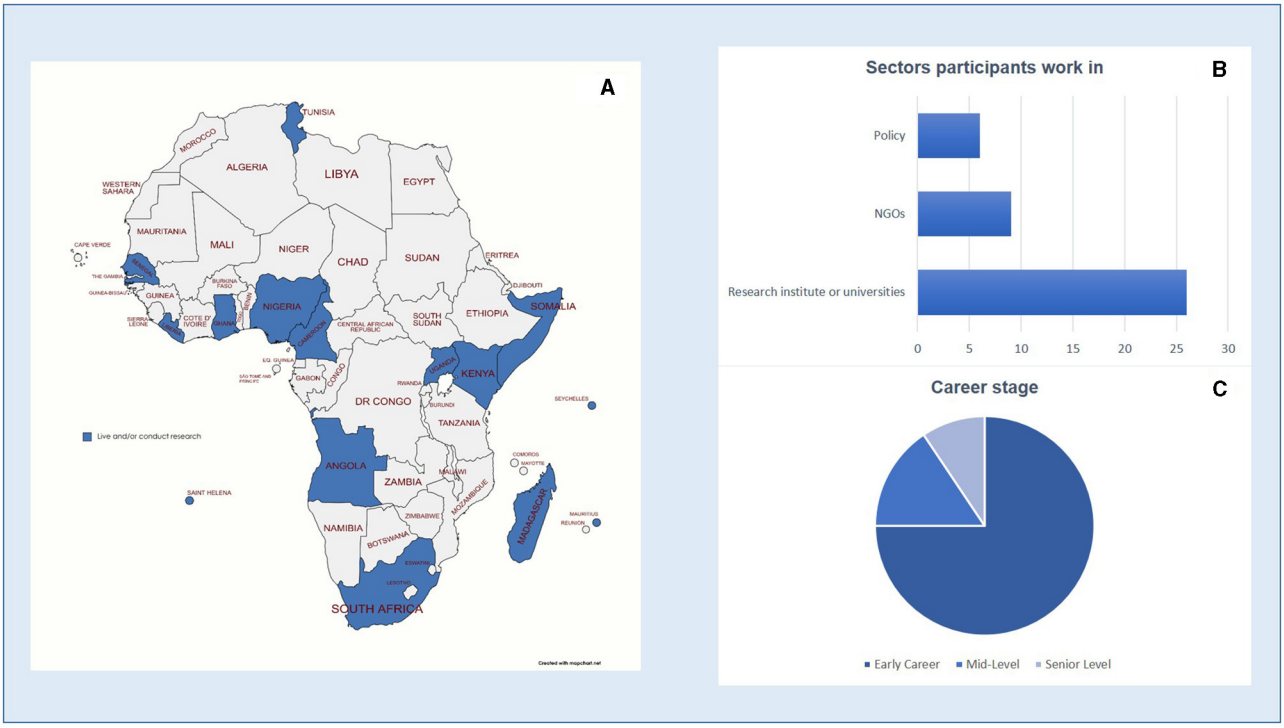

FIGURE 4
Participants profiles. **(A)** Countries shaded blue are where participants resided and/or carried out research. **(B)** Sectors of participants. **(C)** Career stages of participant.

4.2 Data collection and survey

The evaluation of the training course was conducted through a pre- and post-course survey, which was augmented by course observations and final course outputs, such as the co-design proposals developed. During the final day of the training course, a feedback session was conducted to give participants the opportunity to share their thoughts and opinions in a plenary setting. This session facilitated open discussion and mutual exchange, allowing for additional ideas and feedback to be shared. The feedback received during this session was carefully considered and taken into account for the evaluation.

The pre-course survey was designed to serve the following two objectives: (1) collect basic information, including participants' professional background, previous experiences with course-related content, and current preference in course design, (2) assess participants' self-perceptions of their knowledge and skills related to co-designing a research project. Both quantitative data (Likert scale) and open-ended questions were included in the survey.

At the end of the course, the participants were asked to reassess their confidence level in co-design topics and skills through the post-course survey, which also included open-ended questions to elicit their experiences during the course. The changes in confidence levels were measured through two-way *t*-tests and paired one-way multivariate analysis of variance (MANOVA). Additionally, the effectiveness of the learning activities and online course technology (e.g., Zoom and Miro) was evaluated through quantitative measures. The effectiveness in this context is aimed at reflecting how well a learning activity or online course technology helps participants to improve their co-design competencies. This was assessed by requesting participants to rate the overall effectiveness of various learning activities and technologies.

Open questions were also included in the post-course survey, to invite participants to think about their experiences during the training course. More specifically, we inquired what aspects of the course they found most useful for their professional development, whether their understanding of co-design was changed, what new skills and strategies they had acquired during the training course, and what aspects should be improved.

The qualitative data collected from the open-ended responses in both the pre- and post-course surveys were analyzed through content analysis based on a grounded theory approach (Kolbe and Burnett, 1991; Cho and Lee, 2014; Lai and To, 2015). This method has already been successfully adopted for assessing the effectiveness and usefulness of training projects, allowing to identify the main features and educational meanings of the professional development experience (Scott et al., 2004; Nino et al., 2015). This assessment, combined with the quantitative data and course observations, provided a comprehensive understanding of the effects of the course.

The survey was conducted online in English using Google Forms, and the participants were informed that their answers would be anonymous and used for research and academic purposes only. The complete list of questions can be found in Supplementary Appendices B, C, and the survey instrument was pilot-tested and reviewed for content validity by the project leaders.

5 Evaluation results

In total, we received 32 pre-course and 28 post-course responses from the 41 participants.

5.1 The effectiveness of training modules

The evaluation of the training modules revealed a positive impact on participants' co-design knowledge and skills. Ninety-two percent of the participants reported that the training objectives were met and that the experience was useful for their studies or work. Additionally, 88% of the participants would recommend the course to others. The course also resulted in the development of 10 proposals for Ocean Decade Actions, the establishment of a self-organized learning hub on co-design, and the expansion of professional networks.

The survey showed that the training was effective in increasing the participants' confidence levels, with an average increase of 34% in eight co-design topics and 27% in six co-design skills from the first to the final week of the course. The results (Figure 5) also revealed that upon completion of the course, more participants felt confident in working with stakeholders from other areas (15% increase) and well-prepared to set up a co-designed project (8% increase in agreement). However, only one of the changes in self-reported agreement from start to end of class was statistically significant based on t-tests ($p < 0.01$ Figure 5).

The qualitative analysis of open-ended survey responses revealed that 23 out of 27 respondents reported a substantial change in their understanding of co-design, with many expressing a better understanding of the concept and the ability to apply their new knowledge and skills on the job, particularly in working with stakeholders and collaboration across disciplines. This is illustrated by quotes from participants when asked about key benefits they obtained:

> *"It helps me understand the different phases of communication and working with people with different backgrounds."*
>
> *"Being able to see the bigger picture beyond my project and see how effective communication can be."*

The lecturers received positive feedback for their expertise, experience, and delivery of the training material, and participation and interaction were seen to have been encouraged in the lectures. Participants particularly welcomed the Africa-focused lecturers and course materials. They mentioned that:

> *"I really enjoyed the African-context specific lecturers and presenters—so more people with context-experience would be great!", "Very useful training which will guide future research in the African region."*

5.1.1 The skills and knowledge that participants improved the most

The results of the evaluation indicated a positive impact of the training modules on participants' co-design knowledge. An average of 34% increase was reported in participants' self-reported confidence levels across eight topics, i.e., joint vision setting, stakeholder engagement, team and trust building, project management, equal partnership building, impact pathway analysis, science communication, and project sustainability. Seven of the eight topics were directly addressed in the lectures, while team and trust building were expected to be improved through learning group activities.

MANOVA results indicate a statistically significant improvement of self-reported participant confidence in topics ($p \leq 0.05$, Figure 6). Of the eight topics, the largest improvements were observed for project management (59% average increase), joint vision setting (55% average increase), and impact pathway analysis (46% average increase). These topics were the ones for which the participants reported the lowest confidence levels prior to the training. The focus on project management skills was particularly meaningful as most participants are at an early stage of their careers and had limited opportunities to work in managerial positions.

Although the improvements in stakeholder engagement and science communication were not the highest, the post-course surveys showed high levels of confidence in these topics, with 15 out of 27 participants indicating high confidence in identifying and engaging with stakeholders, and 14 indicating high confidence in science communication. This suggests that participants are well-prepared for these topics after the training.

Self-reported confidence level improved by an average of 27% with regard to key skills needed in co-design and MANOVA results indicate a statistically significant improved confidence across categories ($p \leq 0.05$, Figure 7). The largest improvements were found for "recognizing uncertainty" (34% avg.) and "adapting research to new information" (32% avg.). However, when examining the general confidence levels after the course, the highest were for "identifying and understanding different stakeholders" and "using common terms to explain complex research."

Due to the limitations of the Likert scale results, we further combined these quantitative data with qualitative analysis for a more holistic assessment of whether and how participants benefit from the course. The qualitative data were mainly generated from the question Q11 "Which of these skills have advanced your knowledge the most?". The most frequently mentioned skill was "identifying and understanding different stakeholders," with 11 participants reporting advancements in this area:

> *"Before the course, understanding and classifying different stakeholders in a project was challenging, but now I can easily draw a table and classify them according to their influence and interest and make an engagement plan. This will help me in project design in my institution as well as for my personal projects."*

This was followed by "using common terms to explain complex research," "project management," and "team building and collaboration." While "recognizing uncertainty" and "adapting research to new information" improved the most in the quantitative analysis, they were mentioned fewer times in the qualitative analysis.

In conclusion, the evaluation results suggest that participants improved in all co-design topics and skills, especially in areas

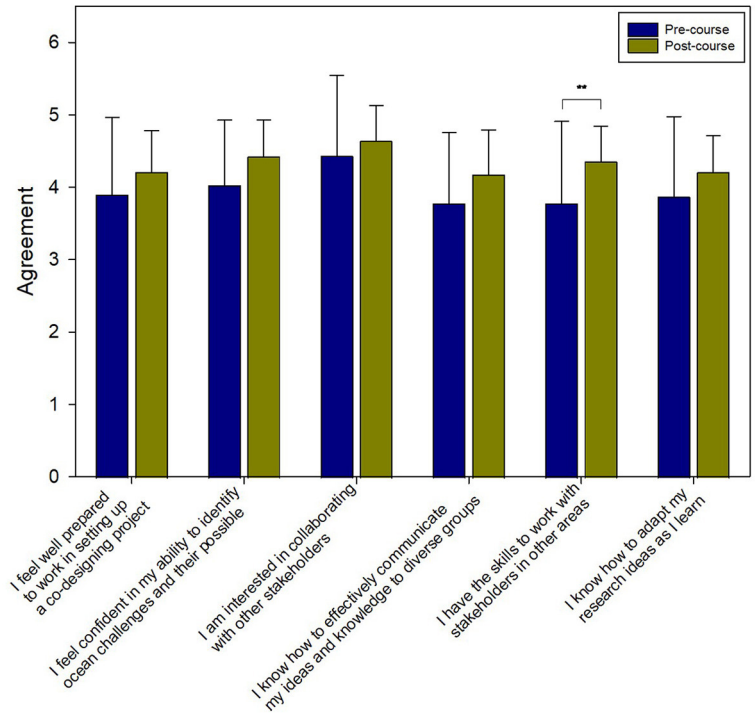

FIGURE 5
Mean agreement rating with different statements based on pre-course (dark blue) and post-course (dark yellow) surveys (error bars denote one standard deviation, $^{**}p \leq 0.01$). 1 = "not at all agree," 2 = "somewhat disagree," 3 = "neither agree nor disagree," 4 = "somewhat agree," 5 = "highly agree".

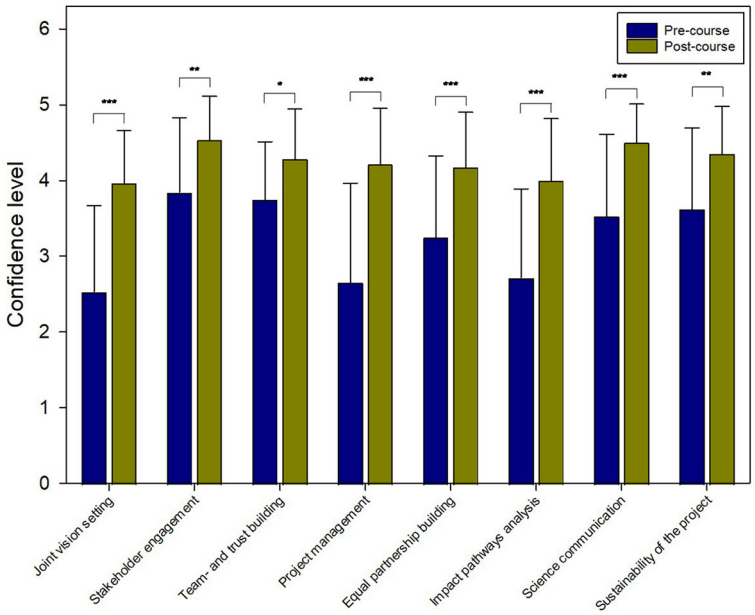

FIGURE 6
Mean self-reported confidence levels for co-design topics based on pre-course (dark blue) and post-course (dark yellow) surveys (error bars denote one standard deviation, $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, $^{***}p \leq 0.001$). 1 = "not at all confident," 2 = "somewhat unconfident," 3 = "neither confident nor unconfident," 4 = "somewhat confident," 5 = "highly confident".

not covered in traditional marine disciplines such as joint vision setting and impact pathway analysis. However, the skills mastered best were "identifying and engaging with stakeholders" and "using common terms to explain complex research." This may have resulted in part from the range of backgrounds participants had, requiring them to explain their work to each other in simpler terms and use less specific terminology than they would do in their daily work lives.

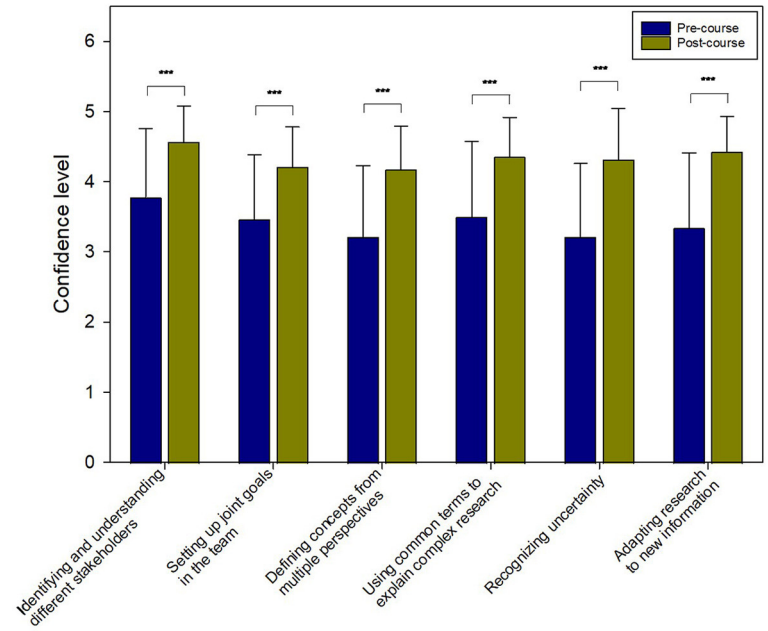

FIGURE 7
Mean self-reported confidence levels for co-design topics based on pre-course (dark blue) and post-course (dark yellow) surveys (error bars denote one standard deviation, $^{***}p \leq 0.001$). 1 = "not at all confident," 2 = "somewhat unconfident," 3 = "neither confident nor unconfident," 4 = "somewhat confident," 5 = "highly confident".

5.1.2 The skills and knowledge participants like to improve further

We also investigated which skills and knowledge participants would have liked to advance further by analyzing the following two open-ended questions: Q12. "Which of these skills (or others not on the list) would you like to advance your knowledge in the most but were unable to practice further in this class?"; Q18 "What do you still need to do to improve your co-design research skills?"

It appeared that the participants would like to further advance their knowledge in recognizing uncertainty and risk management, as well as joint vision setting. Despite the limitations of online classes, collaboration within learning groups still provided some experience working with people from different backgrounds. However, participants felt that actual co-design practice would have been more beneficial with more dedicated time or if the course was in-person. As one of the participants wrote:

> *"I think the actual practice of co-design was difficult with the project teams, as we all had limited time and it would have been highly beneficial if specific time was set aside for this—or particularly if the course was in-person."*

Interestingly, even though "recognizing uncertainty," "setting joint goals," and "defining impact pathways" were among the skills that improved the most according to self-reported confidence levels, they were still frequently mentioned as areas for further improvement. This highlights the demand for continued training in these areas, as one of the participants said:

> *"Impact pathway analysis is one of the skills that I am not fully confident in, but I would like to understand it more and see how best I can integrate it into future projects."*

When it comes to the next steps for improving skills for co-designing research, participants mentioned the need for funding and practical experience, as well as for further training and research. In particular, they noted the necessity to add how to monitor and evaluate co-designed projects. These responses indicate that participants were eager to apply what they have learned in the course to real-life projects, and that continued training should focus on project evaluation, practical applications, and funding opportunities.

5.2 The effectiveness of training activities

The results of the evaluation indicate that open discussions and pre/post-course readings and assignments were the most effective activities, with 16 participants reporting them as very effective and 11 as somewhat effective. On the other hand, breakout group discussions proved to be a controversial activity, with two participants finding them not effective (Figure 8). They reported that working with unfamiliar learning group members led to difficulties in discussion.

However, other participants appreciated the opportunity to work with individuals from different backgrounds, as it provided a new perspective. Yet, tensions arose in some cases due to conflicts

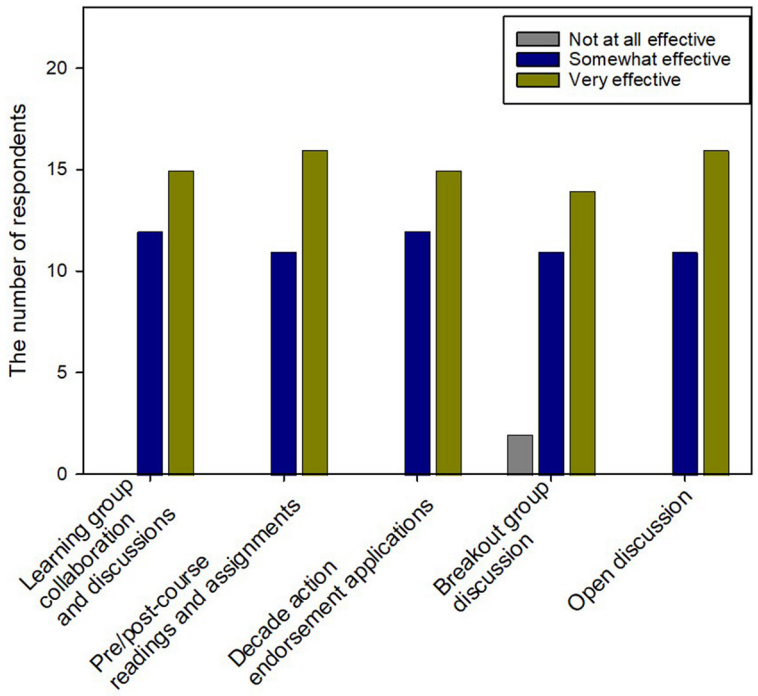

FIGURE 8
The effectiveness of training activities (mean response scores).

in task assignments, leading to the need for accountability, as one participant mentioned:

> *"Although I find the group formations effective, we should hold people more accountable if they share an idea and agree to work collaboratively on it, rather than lead people on and refuse to work collaboratively or at all."*

Additionally, participants mentioned the challenges of working with people from different sectors and backgrounds, as well as the limitations of the online format. Despite these challenges, the online course format has also provided some benefits, such as removing geographic limitations and reducing overall costs and carbon footprint associated with travel. Encouraging proposal preparation helped participants to practice reflection, systems thinking, and communication skills. Combining learning group collaboration with nested discussions also improved participants' resonance with the activities and helped them to better understand their personal reflections. Overall, participants recognized the value of integrating different training activities within the course, as they believed that it would help to facilitate collaboration and provide more opportunities for hands-on experience.

5.3 The core competencies participants found most valuable for co-design

The results of our analysis show that effective communication competence, especially in the context of stakeholder engagement, was deemed critical for successful co-design research. This was mentioned 11 times by participants. Many specific communication skills were mentioned, such as open-mindedness, willingness to learn, and deep and meaningful listening. Reflexive competence was also identified as an important aspect, as participants emphasized the importance of understanding concepts from multiple perspectives. Moreover, systemic project management was identified as an important aspect, as participants emphasized the importance of detailed management and communication skills.

Additionally, the ability to work in a team and systemic project management were also considered essential for co-designing research by many participants. This finding provides empirical support for the conclusions of other studies (Hsiao et al., 2018; Nyboer et al., 2022; Satterthwaite et al., 2022) that call for stronger emphasis on communication capacities and other non-disciplinary skills.

In conclusion, communication competence, especially in the context of stakeholder engagement, and reflexive competence were the most frequently mentioned areas that are crucial for conducting successful co-design research. These results suggest that participants recognize the need for greater training opportunities in stakeholder engagement and soft skills in academic institutions, where the primary emphasis is often on strengthening disciplinary knowledge. Though disciplinary knowledge is centrally important in academia, it did not seem to be seen as a primary or singular need in the eyes of many participants.

6 Recommendations for future co-design training courses

In the previous section, we thoroughly analyzed the accomplishments and gaps of the training course. As an inference

from the evaluation results, we acknowledge the great potentials of the course:

- It focused on the early stages of transdisciplinary project design and initiation, making it easier to learn and more motivating for participants, particularly those new to these methods.
- As a pioneer among co-design training programs focused on Africa, this course provided valuable insight into the integration of local context into training, especially in less developed regions.
- The unique social-ecological challenges affecting the ocean provide valuable experience for conducting ocean-focused training, which not only contributes to transdisciplinary training in other disciplines, but also offers lessons for future ocean-focused training in other regions.

Based on these findings, we outline recommendations for future training courses in the following three subsections. These support enhanced capacity for transformative ocean science, and ultimately improved ocean governance and sustainability.

6.1 Incorporating local and regional context into the course

One of the major challenges in conducting co-design and collaborative transdisciplinary research is the scarcity of mentorship and opportunities for the development of required skills, particularly for early-career academics in developing regions (Jaeger-Erben et al., 2018; Satterthwaite et al., 2022; Strand et al., 2022a). While there is an abundance of literature presenting conceptual approaches for effective knowledge exchange (e.g., Zhang et al., 2022), their practical implementation often relies on trial and error due to a lack of training and guidance. This leads to a lack of interest from researchers and a shortage of human capacity in the region.

While co-design methods and principles, such as inclusive engagement of all relevant societal actors and perspectives, are well-established, some scholars question if they are too standardized and rigid to address the varying contextual conditions across countries and regions (Schneider et al., 2022). They argue that co-design and transdisciplinary work necessitate pragmatic adaptations in different contexts.

To address these challenges, it is essential to design training programs that consider local contexts. This can be achieved by: (1) including both international and regional/local experts as instructors and fostering direct interaction and discussion on diverse practices; (2) incorporating local methods of communication, research, and learning; (3) encouraging participants to reflect on their own epistemological values and perceptions regarding power dynamics in knowledge production, taking into consideration different research cultures (Strand et al., 2022b); and (4) incorporating explicit theories of change that align with local conditions and ways of working with knowledge. These principles do not only enhance transformative research capacity, but also apply more widely to actors, such as staff of regulatory agencies, involved in marine governance.

6.2 Integrating co-design training into ocean science education

The long-term success and sustainability of co-design projects relies on the combination of capacity building and research. For students and young scientists to effectively learn and practice co-design in their education, they must be exposed to such training that sensitizes them to the value of research in this context (Pearce et al., 2018; Collazo Expósito and Granados Sánchez, 2020).

In traditional ocean science disciplines, students who are only trained in one specialized field may struggle to work in a collaborative and interdisciplinary team. Interdisciplinary training helps students gain an understanding of other fields, but it is not enough to effectively address complex ocean challenges. A problem-oriented framework, rather than a discipline-oriented one, is needed to address these challenges. This requires a broader analytical focus that takes into account various perspectives from different sectors and the civil society (Nicolescu, 2018).

University education can play a crucial role in providing students with the skills and motivation to tackle complex, real-world problems through transdisciplinary research (Budwig and Alexander, 2020). It is important for students to understand that addressing real-world problems requires a systematic approach, beyond just working within a disciplinary paradigm. To effectively conduct co-design projects, students must also develop competencies in project management, communication, and conflict resolution (Fam et al., 2017).

Some ocean science programs, such as the Marine and Antarctic Science Master's Program at the Australian Institute for Marine and Antarctic Studies (IMAS), have already started incorporating these skills into their curricula (Gutt et al., 2018). Collaborating with non-academic partners and conducting research on real-world problems can also help students develop important competencies for responsible citizenship while contributing to community wellbeing.

In conclusion, co-design and transdisciplinary work require a specific set of competencies that complement disciplinary expertise. To take co-design research and practice seriously, these competencies must be developed and integrated into university education.

6.3 Embedding co-design research and training in Ocean Decade capacity building

The success of the Ocean Decade, a 10-year initiative launched by the United Nations to support sustainable use and management of the ocean, its resources and ecosystems, will hinge on global capacity building and resource-sharing between countries of different wealth and development levels (Harden-Davies et al., 2022). Embedding co-design research and training into existing capacity development programs within the Ocean Decade can provide several benefits.

Firstly, it can address the unequal distribution of human capacity across the world, generations, and gender. Co-design training can guide capacity development by promoting equitable partnerships and collaboration among multiple disciplines and sectors to address complex ocean challenges and overcome the dominance of certain knowledge and sustainable solutions produced by a few "usual suspects" (de Vos et al., 2023). It can also promote greater inclusivity and diversity in ocean science and management, by involving a wide range of stakeholders and perspectives in the knowledge generation process. This can help to ensure that the needs and interests of marginalized communities are taken into account in decision-making and management practices.

Secondly, co-design of research and management can provide insights for measuring capacity building outcomes and help reflect on key factors influencing capacity development (Harden-Davies et al., 2022). Additionally, involving stakeholders and users in the research process and ensuring that the generated knowledge is relevant and useful to those in the marine conservation and management field can help to build capacity and to integrate results into decision-making and management practices. By integrating co-design training into existing capacity development programs within the Ocean Decade, we can help to build a more resilient and adaptable ocean workforce, capable of responding to emerging challenges and opportunities. This can help to future-proof the marine conservation and management field, and ensure that it is able to respond to the complex and rapidly evolving challenges posed by climate change, ocean acidification, and other stressors.

6.4 Limitations and outlook

As co-design research and training are still in their infancy and, hence, studies on respective training courses are pioneer work, our study has several limitations. Firstly, due to time and resource constraints, this research is limited to a single case study within a specific geographic region. Our initial focus on the African region was driven by a strategic assessment conducted by IOC-UNESCO, which identified a significant gap in co-design Decade Actions submitted from Africa. This highlighted an urgent need for capacity-building efforts tailored to the unique challenges and opportunities present in the region. While this approach allowed for an in-depth analysis of a particular instance, it inherently restricts the generalizability of our findings to other contexts. The unique characteristics and circumstances of the chosen case study may not fully capture the complexities and variations that exist in different settings. While our training was focused specifically on actors interested or involved in the development of research projects, the principles and approaches are likely applicable more generally to the process of ocean knowledge generation. However, training of managers and other actors contributing to aspects of ocean governance beyond research may require additional facets not fully explored by the current course. Furthermore, the social-ecological, economic, and cultural factors that influence capacity development exercises can significantly vary across different regions, thus potentially limiting the transferability of our conclusions and recommendations.

To address these limitations, future research endeavors should consider incorporating larger and more diverse samples, encompassing multiple case studies from various geographic regions. This approach would enable a more comprehensive exploration of the subject matter, providing a broader foundation for drawing conclusions and generating recommendations that hold greater relevance and applicability. Future iterations of the assessed course in the frame of the Ocean Decade would provide additional valuable insights and enhance the lessons that can be drawn for other contexts.

A critical reflection on our work reveals the need to more deeply engage with the complexities of power dynamics in co-design processes. True co-design requires addressing and transforming the power imbalances among researchers, decision-makers, community activists, and other stakeholders. Future efforts will thus delve into ocean equity and justice literature and draw on examples like the Sustainable Seas National Science Challenge in New Zealand which integrates Indigenous and Western scientific approaches (Davies et al., 2018). By doing so, we aim to more effectively confront power disparities and foster a more equitable approach to collaborative research.

Despite these limitations, we believe that our study still holds intrinsic value. The in-depth analysis of the selected case study provides valuable insights into the intricacies of co-design training in that specific context. The recommendations derived from this analysis can serve as a starting point for future courses, prompting further investigation and refinement in diverse settings. By acknowledging the limitations while capitalizing on the strengths of this study, we contribute to the ongoing dialogue and knowledge development in this field.

7 Summary and conclusions

This study showed that, by providing ocean communities with the skills and knowledge needed to participate effectively in the co-design process, co-design training can help to build a more inclusive and equitable ocean governance system that better serves the needs of all stakeholders. The course evaluation highlighted that the effectiveness of a training course depends on several key factors, including the design and content of the module, the delivery method, the qualifications and experience of the lecturers, and the engagement and motivation of the participants. Including participants with a diversity of backgrounds was conducive as well. In summary, a well-designed training course should draw on adequate theoretical concepts and knowledge of required competencies, be research-based and have clear objectives, and should be relevant to the needs and abilities of the participants. The delivery method should combine interactive, problem-based discussion and hands-on learning experiences (learning groups), and the lecturers should be knowledgeable and skilled in delivering the material. The participants should be motivated to learn, and should have the opportunity to apply their new knowledge and skills on the job.

In the context of the Ocean Decade, co-design training is expected to play a key role in promoting transformative ocean science and improving the effectiveness and impact of ocean-related policies and initiatives, by ensuring that ocean communities

are equipped to participate in the co-design process and to advocate for their needs and interests. The results have shown that as a source of diverse expertise and technical capacity, the Ocean Decade is well-suited to provide a training opportunity to craft actionable knowledge through transdisciplinary collaborations, build partnerships with stakeholders, and shape their research efforts in a way to support solutions (Nash et al., 2022). We expect that in the context of the Ocean Decade such training courses can be further supported, by applying these results to a broad range of settings. By doing that, the iterative training model proposed in this study can be used to help train the next generation of ocean professionals in other regions.

As the field of ocean science and management continues to evolve and grow, it is likely that we will see an increase in the availability of co-design and transdisciplinary training programs, as well as a growing demand for individuals with these skills and knowledge. It is critical to ensure that training programs are designed in response to the particular needs and contexts of local and regional communities. Additionally, co-design training should be integrated into ocean science education at universities and research institutes to promote greater awareness and appreciation of this approach to problem-solving. The development of these training programs will also depend on the allocation of adequate resources. We suggest the Ocean Decade to provide funding and follow-up measures to support the continued professional development of those trained, as a one-time training course may have limited impact without access to tools, institutional support, funding, collaborators, or mentors. By doing so, we can expect to see more individuals with co-design skills and knowledge and a greater capacity for transformative ocean science and management.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

JZ, SF, and RL contributed to conception and design of the study. JZ organized the database, performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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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/focsu.2024.1252087/full#supplementary-material

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