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Science Education and the ISC: Report of the Consultative Group on Science Education

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For discussion

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Ministry of Higher Education
Research & Innovation

Science Education and the ISC

Report of the Consultative Group on Science Education to the ISC Governing Board

4 December 2024

Contents

1. Introduction

This report was developed by the Consultative Group on Science Education (hereinafter 'the Consultative Group' or 'the Group'), which was established by the ISC Governing Board in July 2023 in response to requests from ISC Members for the ISC to address issues around science education and science literacy. The aim of the Group was to explore a possible role for the ISC in the area of science education.

The Group was co-chaired by Vice-President for Science and Society Motoko Kotani and ISC Board member Mei-Hung Chiu. The Group was composed of one further member of the ISC Governing Board and ten external experts, including representatives of major international actors in science education (see Annex I). Collectively, the group represented a broad range of disciplines, areas of practice and parts of the world.

The Group aimed to gain a broad understanding of the main issues in science education around the world by surveying what had recently been achieved, what was currently being done by major actors or was in planning, and where the gaps and needs were. The key questions that guided its work included:

- What is needed to improve scientific literacy among young people and the general population across the world, in an inclusive way?
- What is needed to equip scientists, including future leaders, with the tools and skills to address the challenges of today and tomorrow?

The Group met six times, virtually. Each meeting featured 3–4 panellists who presented the state of knowledge, challenges and opportunities in their respective areas of expertise and practice to inform discussion of potential action for the ISC. Issues covered included: enhancing science literacy, inclusive education, transdisciplinary research approaches, resource compilation and dissemination, engaging youth and early career researchers, support for displaced scholars, and communicating with society[1]. The issues and possible responses in each area of concern are presented in more detail in Annex II. Below are summarized the challenges and the recommendations of the Group for possible actions, whether by the ISC or other actors. These recommendations are offered for the consideration of the ISC Governing Board and ISC Members.

2. Global challenges in science education

There are a number of globally recognized challenges in science education at the science-policy-society interface:

- Enhancing science literacy: The ISC promotes science literacy across all age groups, highlighting the importance of scientific knowledge in addressing global challenges and developing skills for future careers. By collaborating with leading international organizations and national academies, the ISC should bridge the gap between scientific understanding and practical application, ensuring that learners are equipped to tackle real-world problems.
- Inclusive education: The ISC vision and mission are fully aligned with efforts to develop inclusive educational strategies for collaborating with communities that cater to diverse audiences, including underrepresented communities. The ISC and community should support initiatives that aim to democratize science education, making it accessible and relevant to all segments of society. This includes creating ambassador programmes and leadership initiatives that empower educators and learners globally.
- Transdisciplinary approaches: The ISC advocates for transdisciplinary methods in science education, integrating various scientific disciplines to address broader societal challenges. This approach involves combining scientific knowledge with insights from the humanities and social

[1] See the Bibliography (Annex III) for an overview of the range of topics considered.

science, emphasizing societal relevance. The scientific community should foster a comprehensive understanding of complex phenomena by promoting collaborative problem-based learning.

- Resource compilation and dissemination: The ISC, together with the community of organizations active in science education, should be committed to gathering and disseminating valuable educational resources and best practices from leading institutions. This effort includes compiling reports, frameworks, and educational tools that can be utilized by educators worldwide to enhance the quality of science education.
- Engaging youth and early career researchers: Recognizing the crucial role of youth and early career researchers, the ISC and the community of organizations active in science education should actively involve them in discussions and decision-making processes. By providing platforms for young scientists to contribute their perspectives, the community of organizations active in science education should ensure the future relevance of science education and foster the next generation of scientific leaders.
- Support for displaced scholars: The ISC should acknowledge the urgent need to support displaced scholars through initiatives like the GYA's At-risk Scholar Initiative. By offering mentorship, professional development, and financial assistance, the ISC and community should help reintegrate these scholars into the academic community, preserving their contributions to science and society.
- Communicating with society: Effective communication of scientific research, both to the general public and to practitioners across disciplines, is and should continue to be a key focus for the ISC to achieve engagement with society by developing a trusted relationship based on dialogue between science and society. Using tools such as newsletters, podcasts, and science reporting, the ISC and the community of organizations active in science education must bridge the gap between science and society and promote transparency and trust in scientific endeavours.
- Commitment to collaboration: The positioning of the ISC should emphasize collaboration with international and national organizations to promote high-quality science education worldwide by establishing a set of high-level common principles that can be applied to the unique systems of each nation. By fostering partnerships and leveraging collective expertise, the ISC and the community of organizations active in science education need to create a scientifically literate and informed global society capable of addressing the challenges of the future.

3. Recommendations for action in science education

The Consultative Group concluded that the following actions are needed in the domain of science education. The ISC could play a leading or important role in recommendations 1–7, while other national and international actors would be better placed and resourced to take up recommendations 8–11.

1. ***Develop 'Global Science Education Principles':*** Create and agree on a set of high-level principles that can be applied worldwide to science education within national systems to ensure that all young people experience a foundation in science that fosters greater knowledge and deeper understanding, provides the technical skills required for the future and empowers all citizens to engage with science in a knowledgeable, informed and critical way.

The ISC is not currently active in this area, but could lead or co-lead a multistakeholder effort. Resources needed would primarily be staff time over 12–18 months.

2. ***Foster transdisciplinary research approaches***

2.1. Collaborate with the university sector to implement transdisciplinary research course requirements across all programmes. Develop and provide a toolkit for designing experiential and research-led courses that equip students with the skills to address complex societal issues. Monitor and evaluate the implementation of these courses to ensure effectiveness.

2.2. Address global challenges with transdisciplinary approaches. Organize collaborative projects and workshops to develop comprehensive solutions, guidelines for action, and science-informed practices. Mobilize funding for transdisciplinary research initiatives and establish a platform for sharing findings and best practices.

This is a key area of action for the ISC. The ISC systematically promotes transdisciplinary approaches (where appropriate), notably in the domain of social and environmental sustainability challenges. In the coming two to three years it will spearhead a new programme of 'mission science' which will be strongly transdisciplinary and which will mobilize funding from diverse sources.

The ISC has experience in promoting transdisciplinary research training initiatives and is ready to support and collaborate with its Members and potential partners, to build capacity for transdisciplinary research.

3. ***Facilitate mentorship and career development***

3.1. Establish mentorship and career development programmes for young scientists, including practical science diplomacy training, opportunities for direct engagement with policymakers and networking opportunities. Develop an online mentoring platform to connect young scientists with experienced mentors.

3.2. Engage youth and early career researchers: Establish ISC-GYA joint programmes that involve young scientists in discussions and decision-making processes. Create a youth advisory council to provide input on ISC initiatives. Organize networking events and leadership development workshops to foster the next generation of scientific leaders.

The ISC has an active programme for Early- and Mid-Career researchers built on the principle of providing a shared space for established and young organizations. This is realized through welcoming organizations of young scientists into the ISC family; financially and morally supporting their participation in ISC initiatives, including through the Early- and Mid-Career Researcher Forum established in 2023; involving them in governance and project steering groups; developing training programmes targeted at early- and mid-term researchers, e.g. training in science advice and science diplomacy expected in 2025–2026.

4. ***Mobilize and provide support to displaced scholars:*** Provide mentorship, professional development and financial support to reintegrate displaced scholars into the academic community in collaboration with a wide range of international science communities. Establish a fellowship programme that offers temporary academic positions and funding for research projects. Develop partnerships with universities and research institutions to facilitate the reintegration of displaced scholars.

Guided by the ISC Committee for Freedom and Responsibility in Science, the ISC is very active in this area. The ISC is collaborating with the International Institute of Education/Scholar Rescue Fund to develop a mentorship programme that will match its Members with displaced scholars. The programme should be launched in 2025, subject to final approval and financing.

5. ***Enhance communication with society:*** Improve science communication by building trust, promoting inclusivity and engaging marginalized groups. Promote effective communication with government and

industry and use innovative methods of public engagement to ensure high-quality science education and combat misinformation.

The ISC has put significant efforts into communicating with non-academic publics in recent years and will continue to promote initiatives to enhance communication between science and policy and improve trust in science.

6. ***Develop a science education webpage on the ISC website:*** Establish a dedicated section on the ISC website focused on science education. This page would feature educational resources, reports, frameworks and tools developed by ISC and its partners, along with news updates, national science policy initiatives, and event announcements.

This recommendation could be acted on in the near term.

7. ***Create a Global Science Education Platform:*** Develop and launch an online platform that facilitates the exchange of information, best practices and resources related to science education. This platform will include forums, resource libraries, and collaboration tools for ISC members and a wide range of educators, researchers, and policymakers.

This recommendation could be an extension of Recommendation 9, but is probably better carried out by other international actors already active in the field, with input from the ISC.

Recommendations for other actors

8. ***Organize international workshops and conferences:*** Plan and host annual international workshops and conferences on science education. These events will bring together experts, educators and young scientists to share knowledge, foster collaboration, and address current challenges in science education.
9. ***Promote problem-based learning (PBL)***: Create a comprehensive programme to promote PBL, including developing guidelines and resources for its implementation. Offer training sessions and workshops for scientists as educators to help them integrate PBL into their curricula. Provide ongoing support through a dedicated PBL helpdesk and resource centre.
10. ***Support digital technologies in education:*** Launch a programme to enhance the use of digital tools in science education. This programme will include training for scientists as teachers on integrating technologies such as simulations, remote labs, and augmented reality into their teaching. Provide grants for schools to access the necessary infrastructure and tools. Support for teachers in facilitating personalized learning that digital technologies will allow and that all young people progress their scientific learning at a pace that suits their ability and level of development/ maturation.
11. ***Promote inclusive science education:*** Develop and support ISC's science education strategies that cater to diverse audiences, including underrepresented communities. Launch ambassador programmes and leadership initiatives to empower educators and learners globally. Provide funding and resources for community-based science education projects.

Annex I. Composition of the Consultative Group on Science Education

A) Composition of the Consultative Group

Group members

1. Motoko Kotani, Tohoku University, Japan (Co-Chair)
2. Mei-Hung Chiu, National Taiwan Normal University, China-Taipei (Co-Chair)
3. Irasema Alcántara-Ayala, National Autonomous University of Mexico (UNAM)
4. Yuri Belfali, OECD
5. Karina Batthyány, CLACSO, University of the Republic, Uruguay
6. Jacquie Bay, University of Auckland, New Zealand
7. Mark Ferguson, European Innovation Council
8. Peter Finegold, Royal Society UK
9. Kevin Govender, IAU Office of Astronomy for Development
10. Hiromichi Katayama, UNESCO
11. Joseph Krajcik, Michigan State University, USA
12. Chee-Kit Looi, The Education University of Hong Kong
13. Magdalena Skipper, *Nature*
14. Jane Yau, DIPF Leibniz Institute for Research and Information in Education

Akiyoshi Yonezawa, Tohoku University, Japan (facilitator)

Invited speakers

1. Saja Alzoubi, Saint Mary's University, Canada
2. Mark Balendres, De La Salle University, Philippines
3. Encieh Erfani, University of Mainz, Germany
4. Alma Hernanadez Mondragon, CINVESTAV (Center for Research and Advanced Studies of the IPN)
5. Marie McEntee, University of Auckland, New Zealand
6. Thomas Tagoe, University of Ghana, Ghana

Annex II. Considerations and proposed actions related to critical dimensions of science education

A) Transdisciplinary approaches in science and the role of international scientific communities

The ISC is at the forefront of promoting transdisciplinary approaches in science to address global challenges by fostering integration across disciplines, thus enabling comprehensive and effective solutions to complex societal issues.

Transdisciplinary transcends traditional disciplinary boundaries, integrating scientific and societal insights. This approach emphasizes collaborative problem-based learning, combining scientific knowledge with humanities to include ethics, philosophy, and societal relevance, advocating to foster transdisciplinary competencies through diverse methodologies.

- Integrate knowledge systems: Science education needs to integrate different knowledge systems, including scientific, indigenous, traditional and community knowledge. This integration aims to broaden the scope of science education beyond mere problem-solving, fostering critically engaged citizenship and transformative learning. A commitment to transdisciplinary approaches at all levels of education should be promoted, ensuring that learners understand the relationship between science and society.
- Responding to common global challenges: The increasing threat of global disasters highlights the limitations of existing approaches. Comprehensive strategies that combine academic research with practical application and align disaster risk reduction with broader development goals are needed.
- Collaboration for Big Science themes: The big science themes, such as astronomy, exemplify transdisciplinary by integrating multiple disciplines to explore. International science communities play a role in uniting different sciences and their scientific communities in efforts to extend their reach in education, development, and outreach. Collective interdisciplinary efforts to address global challenges need to be encouraged.
- Challenges and strategies for collaboration: Interdisciplinary collaboration faces challenges, such as different terminologies and methodologies. Strategies for fostering collaboration include starting projects with social gatherings to bridge gaps and building common goals while respecting the objectives of different partners. The need for facilitators who understand multiple fields should be highlighted.
- Encouraging young researchers: Encouraging young researchers to engage in transdisciplinary research is a key concern. The value of transdisciplinary work for career development should be emphasized and funding mechanisms to support such research should be discussed. Promoting transdisciplinary practices and connecting with communities outside science needs to be underscored.

Actions required:

The ISC should foster transdisciplinary research and education, ensuring a holistic approach to addressing global challenges and promoting sustainable development. Proposed next steps include organizing workshops and exploring funding mechanisms for transdisciplinary projects, especially those involving community engagement.

B) Programmes, opportunities and incentives in developing a capacity building for transdisciplinary approaches

Various programmes, opportunities, and incentives can motivate and foster individuals capable of adopting transdisciplinary approaches to tackle complex global challenges. These programmes enhance skills in collaboration, critical thinking, and problem-solving across multiple disciplines, actors, and stakeholders.

- Problem-Based Learning (PBL): The importance of PBL in preparing students for transdisciplinary scientific endeavours should be emphasized. PBL fosters deep understanding and application of scientific ideas and practices, emphasizing essential 21st century skills such as collaboration and innovation. These have always been an essential part of science, but have become more prominent. By integrating core disciplinary ideas, scientific practices, and cross-cutting concepts, students can comprehensively address complex phenomena. The approach engages students through real-world problems and phenomena relevant to their lives, encouraging active exploration and inquiry. Evidence shows significant improvements in student understanding and achievement, highlighting the need for well-designed educational resources and ongoing teacher development.
- The transformative role of digital technologies: Digital technologies shift the focus from rote memorization to developing critical thinking and problem-solving skills, enhancing students' ability to apply scientific concepts in real-world scenarios. Integrating standards like the Next Generation Science Standards and PISA frameworks emphasizes scientific practices and inquiry. Technologies such as simulations, remote labs, and augmented reality enrich science education by facilitating hands-on experiments, data analysis, and collaborative learning. However, effective use of digital technology requires teachers to acquire new skills through models like TPACK, which blend content, pedagogy, and technology. Adopting these technologies also faces challenges, including the need for robust infrastructure, equitable access, and updated assessment methods.
- Integrating transdisciplinary learning: Much of the potential for innovation lies at the intersection of traditional (scientific and other) disciplines. Universities have introduced a transdisciplinary course requirement in all undergraduate programmes that emphasizes the integration of diverse knowledge systems, including Indigenous perspectives. Through extensive cross-faculty collaboration, transdisciplinarity is defined as the interweaving of different knowledge systems to address societal challenges. These experiential and research-led courses are designed to equip students with the skills to address complex societal issues from the start of their university education. The collaborative development process involves significant team building and the use of digital tools to ensure student-centred courses that foster a transdisciplinary mindset.
- Secondary and tertiary education should be linked through transdisciplinary approaches, emphasizing the need for early exposure to these methods in undergraduate education. Participants recognized the challenges of integrating digital and interdisciplinary approaches into the curriculum and the evolving role of teachers in a digitally enhanced learning environment. The gathering of more data on the effectiveness of these methods and ensuring their uptake by students and educators should be encouraged. It should be refined and implement transdisciplinary approaches in science education to develop a talented pool capable of addressing global challenges innovatively and collaboratively.

Actions required:

- Supporting Digital Technologies in Education: Enhancing science education through the use of digital tools such as simulations, remote labs and augmented reality, while addressing the challenges of infrastructure, access and the nature of teachers' professionalism and skills and considering the potential of technology to support individual differences in students.

- Integrating transdisciplinary learning in universities: Implementing transdisciplinary course requirements across all undergraduate programs to prepare students to address complex societal issues.

C) Communicating with society in science: Accountability, Trust, and Engagement

To enhance the direct impact of science in society, it is essential to cultivate trust in science through science education and communication. This will enable individuals to develop scientific literacy and scientific thinking skills, thereby strengthening the foundation for scientific progress.

- Responsibility in Science Education: Science education is crucial for fostering critical thinking, problem-solving, and informed decision-making. It must evolve beyond facts and theory to inspire curiosity and instil responsibility toward societal and environmental impacts. Education should prepare students to be active participants in scientific dialogue, emphasizing ethical dimensions, societal implications, and critical evaluation of scientific information to combat misinformation.
- Engagement and Inclusivity: Addressing the knowledge gap, fostering critical thinking and ethical reasoning, combating misinformation, promoting engagement among marginalized groups, and integrating interdisciplinary perspectives require a concerted effort from educators, policymakers, and communities. Science education must be accessible and relevant to all, breaking down barriers and democratizing knowledge to empower underrepresented groups, creating a diverse scientific community. The ISC embraces the need for global standards in science education, promoting responsibility and engagement and related international collaboration to ensure high-quality science education worldwide.
- Communicating with government and industry: Effective communication with government and industry in science education requires building trust and demonstrating competence. Emphasizing generic science skills, such as understanding the scientific method and evaluating evidence, should take precedence over specific subjects in the curriculum, while encouraging self-learning and the use of technologies such as AI. Engaging the general public can be achieved through innovative methods such as science competitions and stealth programmes that subtly introduce scientific concepts. Industry has a crucial role to play in supporting science education through work placements, internships and targeted donations, and centralized services can link companies with schools, especially in rural areas. Broadening outreach efforts by attracting disinterested individuals through emotionally engaging content and leveraging their existing interests can increase the impact of science education initiatives.
- The role of publishers in science communication and assessment: Publishers play a critical role in promoting both disciplinary and mission-driven science. It is essential to emphasize the importance of communicating research to the general public and practitioners across disciplines through tools such as science news coverage, newsletters and podcasts. Publishers support diverse research agendas through multidisciplinary and thematic journals but face challenges in evaluating interdisciplinary research due to traditional discipline-specific training and peer review systems. There is a need for a more comprehensive approach to evaluation that includes teaching, peer review, mentoring and contributions to open science. As interest in research with real-life impact grows, better metrics are needed to measure contributions to policy change and practical applications. The scientific community, including academic leaders, funders and learned societies, should work together to drive a culture change in research evaluation.

Actions required:

- Promoting inclusive and engaging science education: Ensuring science education is attractive, maintains high standards, and is accessible to all, with a focus on knowledge sharing and resource provision.

- Towards a Holistic Evaluation Framework: There is a need for a more comprehensive approach to evaluation that includes teaching, peer review, mentoring contributions to open science, and real-life impact.

D) Voice of Next Generation Scientists on Training and Careers for Scientists

The focus of the discussions was on training and mentorship programmes to promote science education and literacy through interdisciplinary dialogue and mentorship in forging the next generation of scientists' inclusive leadership, science communication skills, and engagement in international projects to address global challenges.

- Community engagement: The role of young scientists in ensuring links between societal needs and science, such as food security through plant pathology, is highlighted. The need for community engagement and ISC support in the form of training, funding, access to information, and mentorship is advocated.
- Promoting scientific literacy: Young scientists are responsible for driving change and promoting scientific literacy. The ISC is being called on to provide more support in terms of mentoring, funding, tailored training programmes, and advocacy for the professionalization of roles such as science advisors.
- Support for displaced scholars: There is an urgent need to support displaced scholars, highlighting the GYA's At-risk Scholar Initiative. Academic communities are called upon to provide mentorship, professional development, and financial support to help reintegrate displaced scholars.
- Role of National Young Academies: The role of National Young Academies (NYA's) in promoting science education and the challenges they face should be well recognized. Inter-academic partnerships, innovative approaches to science communication, and better involvement of young scientists in academic assessment are needed.
- Enhancing science education: It is important to make science education attractive and to maintain high standards in scientific publishing. There is a need for knowledge sharing and resource provision by the ISC and other stakeholders.

There is a need to develop broader mentoring and training schemes. The importance of hands-on science diplomacy training and direct engagement with policymakers is highlighted. Dialogue and collaboration to support the career development of young scientists should be facilitated.

Actions required

- Mentorship and career development: Developing mentorship and training programmes to support young scientists, including practical science diplomacy training and engagement with policymakers.
- Support for displaced scholars: Providing mentorship, professional development, and financial support to reintegrate displaced scholars into the academic community.

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