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Editorial: Future-oriented science education for agency and sustainable development

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Editorial on the Research Topic

Future-oriented science education for agency and sustainable development

The gravity of the climate crisis, the United Nations' Agenda 2030 programme and the related aims of Education for Sustainable Development (ESD) call for a fundamental rethinking of values, aims and pedagogies of all education (UNESCO, 2017, 2021). Such developments pose new demands also for science education research and practice: taking responsible action and contributing to change have been taken up as important aims of school science (Hodson, 2003, 2020). The latest visions of science education and scientific literacy ("Vision III", Sjöström, 2017) stress that students should not only understand the role of science and informed decision-making in the society but also be able to question societal choices and values on the basis of ethical consideration and take action to bring about desirable change. While such agency connects to how one orients toward the future, research has shown young people perceiving the global and societal futures as hopeless and out of their influence (e.g., Cook, 2016; Kaboli and Tapio, 2018). To meet the emerging societal demands, science education should be *transformative* to the students and to the society.

In the field of science education, the themes of agency, anticipation, future and models of change and transformation have gained an increasing (but still too little) attention during the past decade. Some literature has been published in order to develop science education *for action* and to facilitate students' *action competence* in socio-scientific issues (Hodson, 2020). Several initiatives promoting futures thinking, foresight, imagination and future narratives in science classrooms have been reported (e.g., Lloyd and Wallace, 2004; Paige and Lloyd, 2016; Levrini et al., 2021; Laherto and Rasa, 2022; Rasa et al., 2022). A number of research publications and white papers have focused on a variety of competencies people need in the future (e.g., European Commission, 2015; European Commission Joint Research Centre, 2022). Such skills typically relate, at least implicitly, to an individual's agency and ways of perceiving the future. Besides the research on students' learning and transformation, some initiatives have focused on institutional level changes: the emerging objectives necessitate the exploration of alternative scenarios for schools, e.g., *open schooling* (European Commission, 2015).

Yet, more theoretical, empirical and practical work is needed to support transformation both at institutional and individual levels, and put into operation the potential of science education in fostering students' agency and futures thinking for sustainability. To this end, and to facilitate new syntheses of theoretical and methodological approaches, we undertook this Research Topic, "Future-Oriented Science Education for Agency and Sustainable Development."

The 33 authors in 10 peer-reviewed papers all considered the need to rethink the nature of science teaching and learning, and motivated this need by referring to the era of great uncertainty or the urgent need for climate action. Their papers set out to explore ways in which science education can support agency and/or futures thinking.

Laying the research-based groundwork for future-oriented education, one of the papers explores tensions in students' imagination of the future (Barelli et al.). Three papers focus on competencies that future-oriented science education should aim to develop in students. One of them investigates policy-makers views on what kind of competencies constitute 'future-oriented skills' (Ioannidou and Erduran). The two other papers focus on specific competencies and their mutual connections: the relationship between students' anticipatory competence and environmental awareness (Ratinen and Linnanen), and teachers' systems thinking competencies and the sense of personal and collective responsibility toward actions (Uskola and Puig).

Three papers deal with pedagogical approaches and concepts, all aiming to revitalize the connection of science education to teaching and learning of other subjects and domains of the world. The proposed approaches and concepts involve holistic science learning (Lloyd and Paige), transdisciplinary collaboration (Kubisch et al.) and, more generally, a *subject didaktik* model for embodied and relational science teaching and learning (Yavuzkaya et al.).

Finally, three papers set out to investigate the effect of more specific teaching-learning activities developing students' sense of agency and perception of the future: activities of fictional writing and scenario building (Hervé and Panissal), activities of analyzing real-world data and scientific argumentation (Rap et al.), and computational simulations on complex systems (Barelli).

The final outcome of this Research Topic provides a multifaceted collection of theoretical and practical initiatives for orienting science education toward the future in a research-based manner. Together they pave the way for building the response of science education to the "new social contract for education" proposed by UNESCO (2021).

Author contributions

The editorial was written by AL. Commented and revised by SE and OL. All authors contributed to the article and approved the submitted version.

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.

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