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EDITORIAL

Science Education and the Pandemic, 1 Year On

Emergence of New Conceptual Tools and Re-calibration of Existing Educational Approaches

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One year has passed since my editorial about science education in the pandemic era was published online in March 2020. In one sense, it feels as though a longer period has elapsed. In another sense, it only seems a few weeks ago when I was pondering about what the impending pandemic meant for research on the applications of history, philosophy, and sociology of science in science education. Our experience of time can seem distorted and confused at times during this pandemic, as evidenced by the typographical error in that editorial where I referred to my doctoral student's research taking place in February 2019 when only 1 month had elapsed. Time seems to have taken a different meaning in our everyday lives, but can "time" emerge from its benign presence in our research endeavours to become a focus of investigation for science education? In a recent paper, Levrini et al. (2021) have explored precisely this question by referring to concepts such has "alienation from time", "time re-appropriation", and "era of future shock" and drawing on perspectives from *sociology of time* to understand how students' daily rituals in schools detach their science learning from broader societal issues. Such concepts are providing us with new ways of interpreting what the pandemic has meant for science education in the past year.

Indeed, the pandemic context is helping researchers galvanize new and fresh perspectives on how to understand and improve science education to make it relevant for today's circumstances. In this issue of *Science & Education*, Pietrocola and colleagues characterize the Covid-19 pandemic as "manufactured risk". The authors question new roles for science education based on "risk society theory", a conceptual framework that can act as a tool for understanding how to align science education with the contemporary demands on problem-solving. They argue that students are unable to deal with manufactured risk because of the type of problems they are usually prepared to solve at school and the limited risk perception they possess. The authors propose the integration in science courses of "wicked problems" with a multidimensional schema that they refer to as "amplified risk perception space" in order to identify and assess students' risk perception.

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The circulation of misinformation about the pandemic is a dimension of the challenges that science education as well as the broader society is currently facing. In their article on pre-service teachers' analysis of claims, Saribas and Cetinkaya investigate fallacies, conspiracy theories, and scientific arguments related to the Covid-19 pandemic. The researchers developed and used a rubric consisting of the high, moderate, and low levels of analysis in different categories including evaluation of claims, demarcation of fallacies and conspiracy theories from scientific arguments, and judgment of the credibility of sources. In a similar vein, Archila and colleagues deal with the issue of misinformation in the context of news media articles providing undergraduates with opportunities to explicitly reflect on the ways in which news articles promote the public (mis)understanding of science and engaging them in argumentative classroom interactions. Their study contributes to the development of research-based university science education.

The emergence of the pandemic has exposed the many faces of social injustice including systemic racism in many parts of the world. Lee and colleagues highlight how racial categories from a biological perspective are unconsciously embedded in individuals' cognition including university students studying biology and medicine. These colleagues investigated how Korean college students' conceptualization of race illustrates a typology for distinguishing human diversity: race as a biological concept, race as a social construct, and race as a bio-social mixture. In addressing methodological concerns about students' attitudes towards socio-scientific issues (SSI), Klaver and van der Molen report a large-scale study designed to validate a questionnaire. Based on a literature review within social and educational psychology and sociology, on topics such as attitude development, scientific citizenship, social or civic engagement, and SSI teaching and learning, the authors developed a framework that describes several underlying components of students' attitudes towards SSI. Apart from a methodological tool, the questionnaire can potentially also serve as a diagnostic tool for student engagement in SSI.

A significant issue that has been highlighted during the pandemic is the public need to understand about how science works. In fact, "science in the making" has taken centre stage in daily public affairs calling for understanding of the methods that scientists use in order to generate new knowledge about the coronavirus. Inherent in public discussions is the range of methods that are being used globally to understand how to eradicate the virus, ranging from randomized controlled trials about vaccines to observational studies on the development of diseases. Ioannidou and Erduran address the issue of methodological pluralism, investigating how science teachers understand and view scientific methods, particularly when scientific methods are presented as a diverse array of activities and not just a model based on hypothesis testing. The authors adapted Brandon's Matrix, a philosopher's account to clarify what is meant by diversity of methods for educational purposes. Taking a broader societal perspective on nature of science (NOS), Wan, Zhang, and Wei report a study with Chinese pre-service teachers demonstrating how the Chinese culture influences their views. In particular, Chinese teachers adopted features of the Confucian Doctrine of the Mean either consciously or unconsciously to account for their NOS views. The authors argue that science teacher education in China cannot entirely import the strategies of teaching the classical views of NOS from the developed world, but should develop, design, and contextualize local strategies that are suitable for the training of Chinese science teachers.

In a rare longitudinal study on students' NOS views, Yacoubian examines the development of four students' NOS views over a 13-year period. More specifically, the study sheds the spotlight on students' long-term retentions of their NOS views as well as the long-term

implications of a NOS intervention. Now a university researcher, the author started the journey as a high school science teacher at the time designing and teaching a biology course using a consensus framework of NOS as its focus, contextualized within rich science content, and embedded within an explicit–reflective method. The findings of the case studies illustrate how the four students benefited from the NOS intervention in the short term, yet their patterns of retaining their NOS views were quite different in the long term. Adopting an explicit and reflective approach to the teaching of the history and philosophy of science, Shi argues that philosophical topics also need to be explicitly signposted and discussed in the teaching of NOS in high schools. The author's study investigated an interdisciplinary course on the NOS in a Chinese senior high school using an explicit teaching of philosophy of science topics with subject knowledge in each lesson. The findings suggest that explicit teaching of philosophy of science topics helps students better understand both NOS and the relationship between science, technology, and society.

Collectively, the papers in this issue of *Science & Education* illustrate the relevance of themes from history, philosophy, and sociology of science for science education in the pandemic era. Concepts that are represented in the journal this year from sociology of time and risk society offer some example new tools through which the contemporary issues in science education can be investigated. Furthermore, as we surpass one year since the emergence of Covid-19, it has become apparent how central some key scientific concepts are to the understanding of the pandemic. Chemistry concepts such as "diffusion" and "concentration" as well as biology concepts such as "virus" and "mutation" which are already part of secondary science curricula from around the world underpin much of the public narrative about the pandemic. Other concepts such as "probability", "modelling", and "exponential growth" as well as representational tools such as "graphs" from mathematics are also in wide public circulation although these may not necessarily be explicitly linked to the science concepts in school curricula. The multifaceted nature of the pandemic reiterated the need for interdisciplinary research as well as cross-subject teaching in schools.

The pandemic has also exposed a face of science in the public sphere, arguably in less subtle terms than ever, demanding understanding of how science works in relation to the broader political and economic landscape. The pandemic has thus brought to the foreground not only the processes of knowledge generation and decision-making in science but also the values and norms that underpin and surround science in societal context. "Vaccine nationalism" has raised questions about the legal (Santos-Rutschman 2020) and moral (Daley 2020) consequences of the scientific endeavour. University–industry partnerships such as the partnership between AstraZeneca and the University of Oxford have illustrated how science can be intertwined with economic and political agendas beyond the confines of basic research and industrial production (Boffey and Sabbagh 2021). As national lockdowns around the world led to closures of educational institutions, parents have been expected to engage more closely with their children's learning; and teachers and university lecturers have had to adapt quickly to planning and teaching online sessions. Such drastic changes have outlined in no uncertain terms the inequities in access to and possession of resources, whether at an individual, family, community, or national level. When schools, universities, and other institutions of science learning including museums struggle to appropriate their curricula to the current learning needs of their stakeholders, it has become imperative to recalibrate science teaching and learning for relevance in the current context.

Considering the educational issues raised by the pandemic have emerged within the past year and academic publication processes are often lengthier than this timeframe, it is expected

that more research-based accounts of the impact of the pandemic will become available in the next few years. It is worthwhile to note that in response to our call in the April 2020 issue for manuscripts related to the relevance of history, philosophy, and sociology of science for science education in the pandemic era, two papers have been published in 2020, one in August (by Michael Reiss) and another in October (by Erik Fooladi) explicitly addressing the implications of the pandemic for science education. It was possible to expediate such manuscripts thanks to the reviewers' generosity in dedicating their time and efforts to the review process, particularly in the midst of the hardships faced during the onset of the pandemic. Volume 29 in 2020 involved 343 reviewers who are acknowledged in this issue. The dedication of the journal's reviewers has ensured that the research reported in the journal is not only rigorous in quality but also relevant in content for contemporary science education.

Compliance with Ethical Standards

Conflict of interest The author declares no conflict of interest.

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