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EDITORIAL

Editorial Vision for *Science & Education*

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It is my distinct honour to take on the leadership of *Science & Education* as the new editor-in-chief. I am looking forward to serving the journal along with my colleagues Olivia Levrini and Maurício Pietrocola Pinto de Oliveira as the associate editors and Gábor Áron Zemplén as the book reviews editor.

Since its inception in 1992, *Science & Education* has been pioneering scholarship in the applications of history, philosophy and sociology of science (HPS) in science education. It can be argued that the journal along with affiliated association, IHPST, have been instrumental in creating a new research and development agenda in science education. A significant aspect of the research agenda has been the contribution of theoretical investigations on the nature of science and related fields such as mathematics and technology, and the implications for education. The journal has published a diverse array of manuscripts exploring how HPS and related fields, including Science-Technology-Society and Science studies, can be used for the improvement of education. The uptake of the research agenda is increasingly evident in the improvement of the journal's impact factor as reported in his farewell editorial by Kostas Kampourakis, the former editor-in-chief of the journal.

Despite progress in terms of the uptake of HPS as a credible area of research in science education, challenges remain. Although the journal has been a strong voice for underscoring the significance of HPS in the improvement of science education, the appropriation of the message outside of the IHPST community has been limited, particularly in journals dedicated to research in science education including those that focus on particular science domains. Consider, for example, some of the trends highlighted in a recent review of chemistry education research. Teo et al. (2014) reported findings from a content analysis of chemistry education research papers published in two top-tiered chemistry education journals and four top-tiered science education journals from 2004 to 2013. The authors observed that of 650 papers in these journals, only 4 or 0.6% were dedicated to history, philosophy and nature of chemistry.

Science & Education has a distinctive responsibility and opportunity to facilitate the understanding of and attitude towards HPS by the broader science education community. How could the impact of HPS be improved in the broader science education community?

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Before addressing this question, I call for caution in the terminology of "HPS". In this editorial, the term is being used as an overarching concept to denote the area of scholarship that provides meta-perspectives on science and related fields such as mathematics and technology. As such, the reference is also fairly interdisciplinary in that it not only includes history and philosophy but also includes other disciplines such as sociology, cognitive science and anthropology. The diversity of theoretical orientations enriches the understanding of the nature of science from different perspectives and can provide insight into how learning environments can be structured so that science teaching and learning are reflective of how science works. While the journal has so far had an impressive record of supporting such an agenda, the journal's mission needs further articulation. Consider the following statements from the journal's website describing the journal's mission:

> *Science & Education* publishes research using historical, philosophical, and sociological approaches in order to improve teaching, learning, and curricula in science and mathematics. In addition, the journal disseminates accounts of lessons, units of work, and programs at all levels of science and mathematics that have successfully utilized history and philosophy. This journal promotes the inclusion of history and philosophy of science and mathematics courses in science and mathematics teacher education programs. Moreover, it promotes the discussion of the philosophy and purpose of science and mathematics education and their place in and contribution to the intellectual and ethical development of individuals and cultures. To achieve its goals, *Science & Education* fosters collaboration among scientists, mathematicians, historians, philosophers, cognitive psychologists, sociologists, science and mathematics educators, and school and college teachers.

The exclusive focus on science and mathematics in the mission statement of the journal needs to be updated to be responsive to the contemporary landscape of education. Many curriculum reform efforts in various parts of the world have begun to acknowledge the importance of science in relation to related fields including not only mathematics but also information technology and engineering. Consider, for instance, Taiwan, which consistently performs well in international assessments such as PISA. Two core values of the new science curriculum in Taiwan are to develop lifelong learners and cultivate students' subject literacy. Inquiry and scientific practices are two foci of the science guidelines, and the proper use of calculation and computing tools and interdisciplinary applications are advocated in the technology related guidelines. Logical and computational thinking, learning-by-doing and interdisciplinary learning are listed as learning objectives. Similarly, the infusion of "engineering practices" in the *Next Generation Science Standards* in the USA signals another example of curriculum standards that promote STEM teaching and learning. The developments in the curriculum policy landscape are mirrored in educational research. There has been plethora of journals emerging in recent years that have made "STEM education" their very purpose. The research scholarship in HPS cannot be indifferent to such developments in the policy and practice of education if it ultimately aims to engage the various stakeholders in the improvement of education.

The journal has a distinctive edge to contribute to the conceptualization of STEM from a range of perspectives including an analysis of the epistemological underpinnings of STEM. Relevant questions emerge for consideration by the journal in the future. For example, what are the epistemological aims and values of science, technology, engineering and mathematics? Do these aims and values overlap or are there distinctions in each discipline? Are the arguments for the collective and interdisciplinary teaching of science, technology, engineering and mathematics justified from an epistemological point of view? What are the implications of potential epistemological variation in the STEM disciplines for teaching and professional

development of teachers? Are the calls for STEM in education justified at all? How can *Science & Education* be responsive to curriculum policy and research initiatives on STEM? Can the journal learn from the practices and experiences of related disciplinary communities such as sociology of science which has conventionally been fairly vocal about policy issues in science (e.g. Webster 1991)? What can the journal learn from sociology of science to engage further with educational policy? Furthermore, how can the journal shape the development of new policy and research in science education more broadly?

A similar concern about the mission of the journal can be raised about other timely educational issues such as citizenship, social justice, sustainability and environmental education, all themes that are also gaining increasing attention in mainstream science education research as well as curriculum policy. Calls for the inclusion of such broader issues in science education demand consideration of the social dimensions of science. There is global concern about socio-scientific issues such as nuclear energy, genetic cloning and enviromental pollution. The complexity of the challenges such as climate change that our planet faces requires an interdisciplinary problem-solving approach. An epistemologically oriented science education can raise public understanding and awareness of how scientific knowledge is generated and validated. A sociological account of science can potentially help clarify the role that institutions, social actors and policies can play in achieving responsible citizenship. As a journal dedicated to interdisciplinary studies of science, *Science & Education* is well placed to contribute to knowledge about such broader issues that are relevant for science education. While the diversity of the foundational fields (i.e. philosophy, history), related themes (e.g. STEM, sustainability) and learning theories (e.g. Learning Sciences, Cognitive Science) suggest an unmanageable complexity in application to education, the journal is guided by a fundamental goal: to provide a forum for interdisciplinary investigations for the improvement of science education, making "science" the primary focus of the journal, as suggested by the title itself.

A second related but different issue concerns the synthesis of scholarship from Cognitive Science, Learning Sciences, Sociology of Science and Educational Research with HPS scholarship to generate frameworks that can potentially serve educational purposes. Developments in the Learning Sciences have illustrated the complexity of teaching and learning. An ambitious educational goal such as HPS needs to be coupled with knowledge about teaching and learning. Without considering any empirical evidence on how teachers and learners think, reason and learn; or without taking into consideration how actual school systems function in particular contexts, the impact of HPS-based arguments in science education will have limited appeal and impact.

In moving forward, a third issue concerns the journal's adoption of a mission to demonstrate the utility and impact of HPS through empirical investigations. Robust theoretical research on HPS and its applications in science education are, by definition, an inherent component of the journal's mission, and they will continue to have presence in the journal. Such work is essential to foster conceptual clarity for science education. Yet, more empirically based exemplary and successful applications of HPS are essential to convince the broader science education community of the relevance and impact of HPS in education. There is existing research that has effectively addressed epistemic themes empirically (e.g. Kelly 2016). What can we learn from such bodies of literature to improve the use of HPS in science education research?

A fourth objective for the journal is to capitalize on HPS to inform educational research based on science disciplines. Many discipline-based journals have particular weaknesses on

the epistemological foundations of the subjects that they are advocating. The earlier reference to Teo et al.'s (2014) review has already illustrated the significant lack of epistemological and historical insight in chemistry education and science education journals. The journal can offer theoretical articulation and clarification to the body of educational research in science disciplines at tertiary as well as secondary level of education. Engagement of the discipline-based communities with the journal will contribute to the field and present coherence in the education sector in progressions from secondary to university education.

Apart from education in particular disciplines such as physics, chemistry and biology, there is also the informal science learning sector. Informal science learning is an important part of the educational support system for particularly helping young children be generally enthused about science as well as to develop interests in science-related careers. An estimate suggests that children spend only 20% of their time learning in formal educational environments (Sacco et al. 2014), which suggests that informal environments provide the means to augment learning in formal settings and are critical for long-term engagement in science. Intersection of scholarship in informal science learning and HPS is a fruitful territory in broadening the scope of the journal.

Finally, *Science & Education* can raise questions about how educational research can contribute to foundational disciplines such as philosophy of science and history of science. As the journal builds on the various contributions of HPS to science education, the reciprocal relationship can be strengthened to demonstrate how theoretical and empirical work in science education research can help develop perspectives in HPS. For example, there might be methodological approaches (e.g. epistemic network analysis) utilized by science education researchers that might provide useful heuristics for HPS researchers.

In summary, the journal's forward vision is inclusive of but not limited to the following key points:

- Being responsive to developments in educational policy and research, e.g. STEM education, citizenship and sustainability issues
- Shaping the development of new policy and research in science education
- Continuing to provide conceptual clarity through theoretical investigations
- Synthesizing HPS perspectives with frameworks from Cognitive Science, Learning Sciences, Sociology of Science and Educational Research
- Demonstrating the utility and impact of HPS through empirical investigations
- Informing science discipline–based education
- Informal science learning and HPS
- Reciprocal contributions between science education research and HPS

As the incoming editorial team, we invite colleagues from different professional communities to engage in interdisciplinary collaborations and to reflect across disciplinary boundaries so as to forge new syntheses that might benefit science education across the policy, research and practice spectrum. Although *Science & Education* is a research journal and as such, it will continue to publish high quality research, we are hopeful that innovation of the journal will also mean that it is impactful beyond the research communities. In particular, we are hopeful that the research represented in the journal will help inform and improve policy and practice of education, and engage a diversity of stakeholders in HPS-informed science education.

We recognize that we are taking over the editorial management of the journal from an excellent team who have made a significant contribution over the past few years. On behalf of the *Science & Education* community, we thank Kostas Kampourakis, Ross Nehm, Gregory Kelly Charbel El-Hani and Alice Wong for all their hard work. Personally, I would like to thank Kostas in particular for his immense help during the transition period. His support and guidance were immeasurable. It is of course difficult to imagine the journal without the original seminal leadership of Michael Matthews. We aim to build on the previous rigorous leadership so that *Science & Education* can continue to generate new insights for improving science education.

Compliance with Ethical Standards

Conflict of Interest The author declares no conflict of interest.

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