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Editors

Fostering Scientific Citizenship in an Uncertain World

Selected Papers from the ESERA 2021 Conference

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Introduction

From the ESERA Conference 2021 to the Book

This book is part of the book series Contributions from Science Education Research, published by Springer in partnership with the European Science Education Association (ESERA). It gathers a selection of papers presented at the 14th ESERA Conference under the theme *Fostering scientific citizenship in an uncertain world*. This conference, organised by the University of Minho, in Braga, Portugal, from 30 August to 3 September 2021, was held as an exclusively virtual conference due to the Coronavirus situation and travel restrictions at that time. This virtual modality brought together the international science education research community, which allowed sharing of research and engaging in discussion about the pressing issues in science education. Overall, 739 papers (out of which 32 were symposia) were presented at the Conference after passing a double-blind review process by two or three reviewers. The papers (single oral communications, interactive posters, workshops, symposia) were organised into 18 strands based on their topic. In addition, the Conference organisers invited five prominent researchers to give plenary talks. Furthermore, it included three memorial symposia honouring John K. Gilbert's legacy, Norman G. Lederman's legacy, and Audrey Msimanga's legacy. The virtual environment of the Conference did not prevent the organisation from arranging a social and cultural programme which included music, dance, and cooking moments and virtual excursions around Braga and other Portuguese tourist destinations.

After the Conference, we asked for the strand chairs' collaboration in selecting the three best papers from their strands, which they considered the most appropriate for inclusion in this book. For that, they were asked to select papers that attended to the following criteria: showing an interesting and genuine relationship with the Conference theme; being of scientific relevance; demonstrating methodological rigour; and showing originality of the approach and special capability to be visionary and inspirational. We, the editors, analysed this pool of recommended papers and invited authors to contribute their work to this book. In addition, we invited plenary session speakers to submit a manuscript to be considered for publication in

the book. As a result, we ended with 19 chapters, which underwent a rigorous scientific review process guided by the editors before being accepted into this volume in their final form.

An Overview of This Volume

This book is composed of 19 chapters and is organised following the guiding thread of the ESERA Conference 2021. We believe this organisation provides coherence for the discerning reader who wants to immerse himself/herself in the depth of science education in challenging times. The book starts with two chapters (Chaps. 1 and 2) authored by keynote speakers who highlight the sense of uncertainty but with an eye on a hopeful future.

The third chapter (Chap. 3) focuses on the importance of engaging initial teachers' training in science education. The Nature of Science (NOS), an important component of scientific literacy, is approached in the fourth and fifth chapters (Chaps. 4 and 5), the former centred on students and the latter on a textbook analysis.

The subsequent six chapters (Chaps. 6, 7, 8, 9, 10 and 11) describe research in specific subjects: one on geography education, two on biology education, two on chemistry education, and the other on physics education. Some of these subjects are also touched on in other chapters.

Two papers make a transition from specific topics to brain stimulus strategies: the paper on physics education that follows a question-answer line (Chap. 11) and a study including inquiry and argumentation in the early years (Chap. 12). Besides this, scientific argumentation (SA) and scientific inquiry (SI) are the focus of Chaps. 13 and 14.

Subsequently, at this point, COVID-19 is called together with vaccination and pandemic conceptions. These issues establish the continuity and a cascade from SARS-CoV-2 infection, pandemic conceptions, vaccination/inoculation, and climate change (Chaps. 15, 16 and 17).

The book closes with two chapters that tie up loose ends in the diversity of science education topics, showing that instead of any isolated subject, all converge for a significant learning and world-comprehensive evolution. Thus, Chap. 18 approaches a holistic view looking for a combination or coexistence of science, environment, and health. Finally, the last chapter (Chap. 19), written by two keynote speakers, reflects on the importance of science education as social justice and action in an informed and engaged citizenship.

In order to familiarise the reader with the chapter contents, a summary of each one is presented subsequently, highlighting their focus, methods, samples, and future research directions.

Highlights of the Chapters

In the first chapter (Chap. 1), *Cecília Galvão* discusses collaboration and interdisciplinarity as core concepts to prepare young people to act as informed and responsible citizens. The author argues that these concepts have guided the effort to overcome current complex problems and that the critical analysis of reality can constitute an important exercise on an uncertain future that affects us. The discussion is supported by examples of science education for citizenship (a project (EEAGrants – Direção Geral da Política do Mar)) (Faria et al., 2019), the PhD in Sciences for sustainability from the University of Lisbon (Galvão et al., 2021), and the Cost Action on citizen science (Roche et al., 2020), which put in evidence the importance of the dialogue of different areas of knowledge to scientific citizenship.

The second chapter (Chap. 2), by *Jrène Rahm*, makes a case for studying learning and identity in movement, resulting in an understanding and deep appreciation of the complex pathways and learning lives of youth, teachers, and community partners engaged in joint projects. Drawing on two research projects, the author emphasises how learning and becoming in and through relations in STEM is a lifelong process made up of a web of trails marked by historical, social, political, economic, and cultural constraints and processes of power. In light of the two examples, Rahm discusses how a mobility lens provides us with new tools to reimagine the joint design of innovative science learning and teacher education deeply committed to equity and social justice.

Julie A. Luft, signing the third chapter (Chap. 3), discusses three benefits of educational researchers in teacher education studying newly hired science teachers. Hence, investigating this population sheds light on the efficacy of initial science teacher education programming, helps understand the teaching-learning process, and allows to assess the durability of their initial certification instruction. Findings from these studies provide new insights into teacher learning, which can result in new forms of preparation and support programming.

In Chap. 4, *Georgios Ampatzidis* and *Marida Ergazaki* discuss the impact of a story-based learning environment on supporting university students' understanding of NOS. Students read fictional conversations between two eminent scientists, responded to story-based questions, and shared views with the class. The story-based learning environment was effective in supporting students' understanding of NOS.

Chapter 5 is authored by *Beyza Okan* and *Ebru Kaya*, who analysed NOS in the 8th-grade science textbook. Framed on "Reconceptualised Family Resemblance Approach to NOS", the analysis of different textbook sections reveals that epistemic and cognitive categories are more frequent than social-institutional categories, and there is an unbalanced inclusion of the different categories in the different sections of the textbook. Hence, a more holistic representation of NOS is needed.

Starting with geography education, in the sixth chapter (Chap. 6), *Svenja Brockmüller* considers it crucial to provide and evaluate methods to promote students' systems thinking. The author compared students' system competence development using analogue or digital soil erosion models or a combination of both. Framed on the dimensional "Freiburg heuristic competence model of systems thinking", the analyses of variance showed significant group differences. Combined use of analogue and digital models for teaching is recommended to promote systems thinking in the context of soil erosion.

Regarding biology education, in the seventh chapter (Chap. 7), *Leroy Großmann* and *Dirk Krüger* refer that writing lesson plans are part of pre-service teachers' training, and because there are no objective criteria to assess them, they developed criteria to assess lesson plan quality. Their chapter describes the methodology of developing qualitative criteria with inductively identified performance level descriptions and presents one exemplary criterion for each qualifier dimension. Finally, implications for teaching lesson planning in teacher training are provided.

Continuing biology education, in Chap. 8 *Lisa-Maria Kaiser* and collaborators analyse the influence of dissections, videos, and anatomical models on students' state of interest and how these resources influence students' state of interest differently, depending on the degree of disgust regarding dissections. They also found significant interaction effects on cognitive and emotional components of interests. Finally, the authors suggest that anatomical models might be an alternative to dissection for students with high disgust.

Changing the theme, in Chap. 9, it can be seen that *Sandra Pia Harmer* and *Katharina Gross* developed guidelines for analysing chemical explanations videos, which lack superordinate quality control. The procedures included an in-depth literature study on media pedagogy, chemistry-specific content and pedagogical (content) knowledge, an analysis of videos on chemical bonding, and a students' survey. The authors concluded that research is needed on using chemical explanation videos in chemistry classrooms to sensitise students in dealing with video sources.

Also concerned with chemistry, in Chap. 10, *Fabien Güth* and *Helena van Vorst* focus on context-based learning as a method for differentiated instruction in chemistry education. Results show that groups of students differ in terms of their context choice, and situational interest, satisfaction. They suggest that further studies are needed to clarify the benefit in terms of learning outcomes or increased interest.

In Chap. 11, *Frédéric Bouquet* and collaborators tested whether an immersive format could increase students' engagement in experimental physics. Compared with teaching as usual, students' emotional engagement was higher in the context of immersion, no behavioural or cognitive effects were found, and the teaching goals were achieved. They suggest further research in contexts in which students' engagement is known to be poor.

The study by *Inés M. Bargiela* and collaborators, in Chap. 12, explores the role of a teacher when early childhood students engage in inquiry and argumentation practices in the context of learning about forces. The work sheds light on the underexplored research area of teaching-based inquiry practices in early childhood education, providing evidence that it is necessary to reformulate the role of the teacher's guidance as an integral part of inquiry-based teaching in early childhood.

Continuing with argumentation, in Chap. 13, *Jinglu Zhang* and *William J. Browne* explore how items can be written to create a scientific argumentation (SA) assessment and what factors should be considered to improve SA assessment design. Based on Toulmin's model and approaching the three SA competencies (SAC) identifying, evaluating, and producing, a five-round iterative process allowed the development of an assessment instrument. The authors found ten factors influencing the assessment and concluded by discussing on SAC assessment design guidelines.

In Chap. 14, *Verena Petermann* and *Andreas Vorholzer* investigated how teachers use explicit instruction when planning lessons to foster students' scientific inquiry (SI) competencies. Results showed that teachers often include opportunities for students to engage in various inquiry activities (e.g. planning, conducting, and analysing investigations). However, they rarely include explanations of SI concepts and tasks that demand stating, elaborating, or reflecting on them. Potential reasons for these findings and implications for professional development are discussed.

Chapter 15 is the first entry on pandemic issues. *Ruth Chadwick* and *Eilish McLoughlin* identified the impact of the COVID-19 crisis on teaching science within the Irish primary curriculum. Teachers in this study reported several challenges when teaching science during this crisis, including the disengagement of pupils and their families and difficulties when facilitating science activities remotely. However, they also identified positive aspects, such as teacher professional development. Finally, recommendations for mitigating actions to lessen the negative impacts of the COVID-19 crisis are discussed.

Continuing with COVID-19, in Chap. 16, *Uwe Karsten Simon* and *Marc Brack* reveal that adults and secondary students showed mediocre knowledge of COVID-19, knowledge gaps in the deep understanding of virology and vaccination, and several misconceptions. Knowledge was significantly correlated with the level of education/grade. Furthermore, lower-grade high school students performed significantly better than their same-age peers from middle school. Moreover, willingness to be vaccinated was significantly correlated with knowledge.

In Chap. 17, *Thomas Schubatzky* and *Claudia Haagen-Schützenhöfer* show that adolescents are susceptible to present misinformation targeted at the scientific consensus regarding climate change, even in the presence of accurate information. Inoculation treatment led to pre-emptively protecting adolescents against that misinformation and to an increase in the adolescents' consensus estimate, and their belief certainty in their estimate increased. The authors recommend future climate change education research to elaborate on possible applications of inoculation theory in climate change education or other socially controversial issues.

In Chap. 18, *Albert Zeyer* and colleagues present the new concept of science pedagogy, Science|Environment|Health (S|E|H). The authors consider holism an essential view of S|E|H and the Two-Eyed-Seeing concept as the basis for scientific holism. The text refers to a symposium with three contributions, conceptualises Two-Eyed-Seeing in S|E|H, and discusses consequences for teaching and research in science education. Finally, the authors suggest that this topic may be an extension of socio-scientific issues.

The book ends with Chap. 19, where *Christina Siry* and *Hagop Yacoubian* discuss how working towards social justice, as a uniting theme to science education,

can transform contexts of learning and support students in developing values relevant to making informed decisions and taking action. From understanding that science is embedded within social, cultural, and political systems, the authors elaborate on how they envision science education contributing to preparing an informed and engaged citizenry. In addition, supported by their distinct current research projects, they discuss what can be learnt from coming together across differences.

Thus, by gradually unveiling the contents of this book, we hope to have awakened readers' desire to know each chapter in detail. Indeed, we hope you enjoy reading this book as a moment of deep learning, like it was, for us, organising and holding the ESERA Conference 2021 in a context as atypical as it was rewarding.

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