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Xana Sá-Pinto, Anna Beniermann, Tom Børsen, Martha Georgiou, Alex Jeffries, Patrícia Pessoa, Bruno Sousa and Dana L. Zeidler (Eds.), *Learning Evolution Through Socioscientific Issues*, UA Editora, 2022; 219 pp.: ISBN: 978-972-789-822-0

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Learning Evolution through Socioscientific Issues is a vital contribution to how evolution can be mobilised through complex, open-ended and controversial issues that embed science content and practices to inform solutions to the social issues in which they occur (Kinslow et al., 2019). The book resulted from the collaborative effort of an international team of experts that included teachers, science museum practitioners, evolutionary biologists, and science education researchers. The editors and chapter authors have succeeded in presenting a comprehensive collection of testimonies that is very useful for educators, evolutionary biologists, science education researchers, science communicators, policymakers, and other professionals interested in the connections between socio-scientific issues (SSI) and evolution. The book explores a broad range of issues and highlights the connections between evolution and SSI in formal and non-formal educational contexts, scientific literacy, and sustainable development. The book also abundantly presents key factors of evolution teaching and valuable suggestions for educators.

Connections between evolution & SSI in formal education practices

The word cloud of the keywords of the book's chapters shows that the most common word used is education, closely followed by evolution (Figure 1).

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Figure 1
Word cloud of the keywords of the book chapters

The central place of education in this book is not surprising because most of the authors of the chapter have a strong educational background, which is reflected in their approach to evolutionary issues from an SSI perspective. In fact, evolution education is a challenging issue that has long attracted educators' and researchers' attention. One ongoing concern is what educational strategies are effective for promoting students' scientific literacy on evolution. From my perspective as a science educator, teaching it through SSI is a relevant approach to achieving that purpose. Although not limiting itself to formal education, the book has great relevance for educators in formal settings.

Connections between evolution & SSI in formal contexts

Educators interested in practice descriptions to explore SSI and evolution will find them in six complementary chapters that cover an array of specific topics. For example, in Chapter 8, *Evolving cooperation and sustainability for common pool resources*, Hanisch, Eirdosh, and Morgan present a detailed practice description organised in a unit with five lessons, targeting 15- to 18-year-old students, on how people can cooperate and sustainably manage their shared resources. Starting from the presentation of case studies or models based on agent-based computer simulations, students must predict the outcomes of the situation presented. The unit concludes with a project in which students are asked to mobilise their understanding of the complexity of social-ecological systems to analyse a specific SSI. The final task is the communication of results to stakeholders, which is a strategy to promote the project's outreach and develop the students' communication skills.

Also targeting 15- to 18-year-old students, in Chapter 11, *The impacts of solar radiation on our health*, Ponce, Carneiro, Rodrigues, and Topçu present a practice description that explores how the differences in solar radiation across the globe impact the health of individuals with variations in skin colour differently and historically influenced the evolution of human populations. Based on this knowledge, the authors promote the students' discussion of the use of ethnic information to communicate about health issues using an SSI approach. Throughout four sessions, students learn about the evolution of skin colour, skin colour distribution, and the impacts of solar radiation on human health and reflect on a set of questions related to medical and ethical issues. In addition, educators will find questions outlined by the chapter's authors to foster discussion about the previous issues, as well as valuable tips on how to manage the sessions.

In this comprehensive book, high school teachers also can find activities specifically created to explore human evolution with high school students. For example, in Chapter 7, *Opportunities to deal with human evolution*, Siani and Yarden use lactose tolerance, celiac disease, and starch consumption affecting diabetes as topics to explore human evolution. The related activities were created within the framework of four specific design principles and implemented in an online context. The authors argue that discussing genetic evidence with students is one possible way to enhance their knowledge and evolution acceptance. A rationale for this is that, by comparing the DNA sequences of different species, similarities between them can be observed and represented through a numerical score. The activities were also designed to prevent students from putting forward teleological explanations and to promote their understanding of the nature of science. Siani and Yarden also present valuable suggestions for teaching practices, arguing that the use of human evolution examples is a powerful evolution education strategy. For example, the lactose tolerance activity exposed the students to the fact that humans are the product of evolution and are still evolving, just like every other organism.

If the educator is interested in an SSI approach to genetic engineering for 12- to 18-year-old students, Chapter 12, *Are we allowed to tinker with (human) DNA? Addressing socioscientific issues through philosophical dialogue - the case of genetic engineerin*g, provides an interesting activity. In this chapter, De Schrijver, Blancke, Comelissen, Sermeus, and Dunlop propose philosophical inquiry as a relevant approach to address SSI related to genetic engineering. In this approach, students are asked to look for answers to challenging philosophical questions. Specific examples of philosophical questions that do or do not work in philosophical dialogue and philosophical follow-up questions are

presented. Furthermore, the tips for practice presented by the authors concerning the questions that the facilitator can ask students for clarity, arguments, alternative perspectives, implications, consequences, and meta-reflections, help to clarify the management of the philosophical dialogue. Dialogue examples are also presented in the description of the educational practice, and they also prove to be of high value for those educators who are looking for specific examples of how to manage philosophical questions in a genetic engineering context.

If your students are younger, look at the activity in Chapter 10, *Why are pollinators declining?*, proposed by Lewis, Bell and Kent for 11–14-year-olds. Pollinator decline is a major global risk for society because it harms ecosystems services and impacts food production and other aspects of human well-being (Dicks et al., 2021). The authors propose that students act as farmers and reflect on how to balance pollinators' conservation with the unpredictable impacts of environmental and socio-economic factors on the farmers' profits, using a gamification strategy. Throughout the game, students can explore evolutionary biology concepts, such as specialisms in plants and pollinators, co-evolution, or the differential disease resistance between species. Finally, the activity concludes with discussion points to facilitate students' understanding of the complexity of SSI from a societal perspective.

College teachers can also find detailed practice descriptions targeting higher education students in this book. For example, in Chapter 9, *Considering evolution as a socioscientific issue: an activity for higher education*, Cebesoy describes an educational practice about natural selection within the context of antibiotic-resistant bacteria, a major worldwide socio-scientific problem (Centers for Disease Control and Prevention, n.d.; European Centre for Disease Prevention and Control, n.d.). Organised in three lessons, this chapter offers educators valuable suggestions for engaging higher education students with collaborative work around the core ideas of natural selection and its transposition to antibiotic resistance. Furthermore, in the appendix, the author presents the reading materials and additional sources used in the lesson, which are very good starting points for anyone who wants to address this topic.

Connections between evolution & SSI in non-formal contexts

Those interested in exploring the connections between evolution and SSI in non-formal contexts, such as museums, will find relevant insights in Chapter 4, *SSI approach out of schools - How can these approaches be used in science museums and other non-formal education contexts?* Through a case

study approach of three natural history and science museums, Georgiou, Fonseca, Fortin, Turpin, and Roux-Goupille present the reader with interesting examples of how to explore biodiversity, SSI and citizen science in non-formal educational contexts. The relationship between SSI and biodiversity is explored by the Natural History and Science Museum of the University of Porto through hypercubic displays. These displays provide the setting in which the aesthetic, ethical, economic and scientific principles are explored. The theme of biodiversity is also at the core of one activity proposed by the Zoological Museum of the Biology Department of the University of Athens. Presenting to the participants different (endemic and non-endemic) animal species living in Greece, their risk categories and the causes that lead to the extinction of endangered species are the starting points to question the place of humans among other living organisms in order to emphasise that human beings are just one of them. The French National Museum of Natural History focused its SSI approach on a citizen science project, fostering the participation of primary, middle or high school teachers and students in the science project 'Vigie-Nature École' (VNE). By monitoring wildlife, participants engage in decision-making processes related to the conservation of biodiversity in a local context. Using a simple, albeit effective and accurate protocol, participants are invited to make bird observations in urban areas and express the results using a digital tool. This out-of-school activity, although starting from a non-formal context, could be transferred to formal educational contexts. The authors of the chapter discuss that, by experiencing the natural world and becoming immersed in nature, people scaffold their emotional and affective responses towards the SSI issue, which can trigger individual and collective action.

Key factors of evolution teaching

A valuable chapter for all teachers and other educators who wish to address evolution effectively is Chapter 6, *Evolution education and outreach: important things to know about how to teach about evolution*. The authors, Nehm and Kampourakis, alert teachers to the fact that language misunderstandings can compromise learners' comprehension of evolution. To overcome this difficulty, the authors present and discuss common and problematic terms that must be explicitly addressed prior to and during outreach and evolution education. For example, terms such as 'fitness' and 'adaptation' can have different meanings in everyday language and in scientific contexts, and teachers must be aware that some students do not have sufficient content knowledge to apply those terms to evolution contexts properly. Furthermore, the authors also describe a set of

cognitive biases and misconceptions that teachers and science communicators must be aware of when addressing students or the general public. These misconceptions can impact the learners' reasoning and ability to learn about evolutionary phenomena. To overcome those biases and misconceptions, Nehm and Kampourakis offer valuable didactic suggestions, such as a focus on disciplinary core ideas, cross-cutting concepts and science practices. For example, the authors suggest that presenting cross-case comparisons, and aligning the cases presented with the students' interests, could foster their motivation to learn about evolution. A set of pedagogical and assessment approaches that could help teachers evaluate the effectiveness of their evolution education practices and communication is also discussed.

Using 'hooks' to foster and maintain the participants' interest in evolution is a theme addressed in Chapter 5, *How is evolution impacting our lives*, by Jeffries, who presents a point of view focused on the exploration of real-life evolution contexts which impact human life, to engage learners in the topic. The relationship between evolution and ethics, cancer, biodiversity change and Covid-19 are presented as powerful examples of real-life evolution contexts that can act as drivers for evolution understanding by enhancing students' involvement with this topic.

Relationship between evolution, SSI and scientific literacy

As highlighted in the editorial, the chapters discuss, from a variety of angles, the mobilisation of SSI as a valuable pedagogical strategy to develop scientific literacy. According to the National Academies of Sciences, Engineering, and Medicine (2016), one of the common aspects of individual science literacy is the cultural understanding of science. This dimension acknowledges the 'interrelationships of science and society and science and the humanities and recognises science as a major human achievement' (NASEM, 2016, p. 33). These interrelationships of science and society were approached by the authors of Chapter 2, *Using socioscientific issue approach to promote students' scientific literacy*. Sankaya and Topçu outline the connections between two models that can support educators with the development of SSI-Based instruction, the socio-scientific instructional model, first described by Friedrichsen et al. (2016), and the 5E teaching model, developed by Bybbe et al. (2006). The argument is that starting from this framework, educators can explore different visions of scientific literacy and mobilise them to develop competencies in their students.

Connections between evolution, SSI, and sustainable development

The relationship between evolutionary biology and sustainable development is a theme that crosses many chapters of this book but is more explicitly addressed in Chapter 3, *Evolution education through SSI for sustainable development*. Through a systematic literature review, Pessoa, Lopes, Pinto, and Sá-Pinto analyse which evolution key concepts are explored in studies that use SSI approaches to promote evolution education and which competences in sustainability these most often address. In the chapter's Table 2, the authors provide a list of papers addressing specific dimensions of evolution education (history of life, evidence of evolution, mechanism of evolution, and studying evolution) that might be especially interesting for educators looking for inspiration to explore specific dimensions of evolution education in an SSI context. The authors state that, although approaches addressing SSI from an evolutionary perspective are still scarce and not very diverse, they show great potential to foster students' key competencies in sustainability and to empower them to become active promotors of sustainable development. The authors stress the need to diversify and increase the number of approaches that promote evolution education through SSI to develop students' key competencies in sustainability. They also highlight the importance of enhancing the engagement of schools and students with external stakeholders related to diverse SSI and the promotion of collaborative work among the students.

The book *Learning evolution through socioscientific issues* sheds light on the connections between the SSI approach and evolution education. Giving voice to many different experts in this field, the editors were proficient in presenting a wide range of educational strategies to improve the understanding of evolution and the development of socio-scientific reasoning. The cross-disciplinary approach used is remarkable and constitutes a valuable tool for educators that want to address evolution in interdisciplinary settings and different contexts. Although the book presents a comprehensive approach to the issues discussed, it also leaves room for further analysis and reflection. The authors put forward many pressing and valuable questions relating to further studies to better understand the full potential of evolution and SSI.

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