

EDITORIAL

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Teacher preparation and evolution education: challenges and opportunities—introduction to the special issue

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Introduction

Obstacles to teaching and learning evolution have been previously documented and reported. Since biology teachers play an essential role in evolution education, it is important to provide future biology teachers with the competencies needed to cope with these challenges and therefore their professional preparation is key. In a review study of the evolution education literature with a focus on teachers, Sickel and Friedrichsen (2013) analyzed research on K–12 biology teachers and identified five central goals in preparing them to teach evolution: the development of (1) content knowledge (CK) about evolution, (2) understanding of the nature of science (NOS) related to evolution, (3) acceptance of evolution as valid within science, (4) knowledge of and strategies for handling the public controversy, and (5) pedagogical content knowledge (PCK) for teaching evolution. They also stressed that teacher preparation research on evolution should pay more attention to teaching evolution in the classroom. This addresses the finding that declarative knowledge (CK and PCK) prospective teachers learn during their academic preparation at university stays often tacit when later teaching in the classroom. Hence

abilities like professional vision (Steinwachs and Martens 2022) should also be trained during teacher preparation.

Against this background, the goal of this special issue is to focus on challenges for teacher preparation that originate from the unique features of evolution and discuss how to deal with these challenges when preparing future educators to teach evolution.

Contributions to the special issue

In the first article of this special issue, following Roberts and Bybee's (2014) distinction between *science literacy* and *scientific literacy*, Kostas Kampourakis (2022) distinguishes between two types of literacy related to evolution: *evolution literacy*, namely literacy relevant to processes and products of evolutionary biology; and *evolutionary literacy*, which is the literacy relevant to questions that students may encounter as citizens in the future and to the socio-ethical implications of scientific knowledge. This author claims that teaching for evolutionary literacy requires specific skills from teachers, which go beyond their ability to teach concepts and explanations.

Looking at these two suggested types of literacy from Sickel and Friedrichsen's (2013) perspective, it seems that teaching for evolution literacy requires CK, NOS, and PCK (goals 1, 2, and 5, respectively), while teaching for evolutionary literacy requires acceptance of evolution as valid within science and knowledge of strategies for handling the public controversy (goals 3 and 4, respectively). Table 1 describes what the 5 additional articles included in this special issue say about evolution literacy and evolutionary literacy in terms of the five goals for teacher

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Table 1 The foci of the articles that appear in the special issue either on evolution literacy or on evolutionary literacy (according to Kampourakis 2022) and their relations to the five goals for teacher preparation to teach evolution according to Sickel and Friedrichsen (2013)

Kampourakis	Evolution literacy	Evolutionary literacy
Branch et al	Teaching CK—effective for preparing educators to teach evolution (Goal 1)	Teaching creationism/Biblical perspective—ineffective, leading to the presentation of creationism as scientifically credible (Goal 4)
Stahi-Hitin & Yarden	NA	It is important to connect to students' culture and relate to the boundaries between science and religion (Goal 4)
Newall & Reiss	NA	It is important to treat evolution as a sensitive issue due to the existential concerns it elicits (Goals 3 and 4)
Aptyka & Grossschedl	Pre-service teachers' CK about evolution predicts their behavioral intention to teach evolution in biology classrooms (Goal 1)	Pre-service teachers' personal religious faith affects the behavioral intention to teach evolution in biology classrooms (Goal 4)
Steinwachs & Martens	PCK—addressing students' alternative conceptions in evolution classes (Goal 5)	NA

CK Content Knowledge; PCK Pedagogical Content Knowledge; NA Not applicable

preparation to teach evolution listed by Sickel and Friedrichsen (2013).

Branch, Plutzer, and Reid (2023) try to answer the question of what is effective and ineffective in preparing high school educators to teach evolution, using a national U.S. survey with a representative sample of public high school biology teachers. Their results show that pre-service coursework on evolution was associated with positive classroom outcomes: more class hours dedicated to evolution, not presenting creationism as scientifically credible, awareness of the scientific consensus on evolution, and prioritizing human evolution, common ancestry, and the origin of life as topics of instruction while avoiding Biblical perspectives on the history of life. Surprisingly, pre-service methods coursework on problem-based learning and teaching controversial topics was significantly associated with negative outcomes, including presenting creationism as scientifically credible. Their findings suggest that pre-service coursework in the U.S. at present adequately prepares biology teachers to teach for evolution literacy but may not adequately prepare them to teach for evolutionary literacy by counterproductively leading to the presentation of creationism as scientifically credible in the classroom.

While Branch et al. (2023) in effect presuppose, following the general approach of U.S. science education, that evolution literacy is the chief goal of evolution education, contributions in this issue by Stahi-Hitin and Yarden (2022) as well as by Newall and Reiss (2023) take a different track. The study presented by Stahi-Hitin and Yarden (2022) addresses the disagreement between whether teachers should teach for evolution literacy (focusing on teaching evolution CK) or whether teachers should teach for evolutionary literacy (specifically by relating to students' religious faith in evolution class). The findings of

a survey conducted by these authors point to a difference between scientists, who were of the opinion that biology teachers should not relate to religion in evolution class, and teachers, who argued that biology teachers should relate to religion in the context of teaching evolution. The findings of in-depth interviews conducted with religious scientists and teachers indicated that the religious teachers thought it is important to connect to the students' inner world, culture, and self-choice, by relating to the controversy when teaching evolution. However, the interviewed religious scientists stressed that the boundaries between science and religion should be emphasized clearly by the teachers. In addition, these scientists stressed that biology teachers themselves should not discuss the issue, but that it is preferable that an external figure, such as a rabbi or a religion / Bible teacher, should do it. The teachers should focus on solely teaching science. Stahi-Hitin and Yarden (2022) suggest a few educational practices that a professional development program for teachers may include: for example, considering that students have a free choice and a personal belief system, examining the different solutions to the conflict that each culture has, and defining the borders between religion and science, thus preparing the teachers to concerns that may arise in their lessons.

The paper by Newall and Reiss (2023) presents findings that point to existential concerns encountered while learning evolution as an additional challenge encountered by teachers and teacher educators. The authors conducted in-depth interviews with students studying towards education qualifications and found that since the topic of evolution concerns issues that deal with death, extinction, and change, it can be deeply unsettling for many people. Accordingly, the authors suggest that when teaching evolution teachers should consider at least three

possibly overlapping difficulties: the topic is cognitively challenging (as previously suggested for reaching evolution literacy), it may conflict with the learners' religious faith (as previously suggested for reaching evolutionary literacy), and their new suggestion that it may be uncomfortable due to existential concerns (which can be another obstacle for reaching both evolution literacy as well as evolutionary literacy). The authors therefore suggest two pedagogical approaches that should be taken by teacher educators, namely, to treat evolution as a conceptually demanding topic and as a sensitive issue.

The study of Branch et al. (2023), as well as the study of Steinwachs and Martens (2022; see below), identifies opportunities to advance the preparation of future biology teachers to teach evolution. The study of Aptyka and Großschedl (2022), in contrast, aims to elaborate and analyze factors (e.g., knowledge about evolution, personal religious faith) that foster or hinder biology teacher students' behavioral intentions to teach evolution aiming for students' evolutionary literacy. The authors adopted a behavioral psychology research perspective and derived a research model based on the theory of planned behavior to examine behavioral intentions to teach evolution. They amended the model using variables shown earlier in teacher education research to be essential determinants for the behavioral intention to teach evolution. A hypotheses-driven quantitative cross-sectional study with pre-service biology teachers was conducted by using an online questionnaire. The data were analyzed by applying a two-stage structural equation model. Among the results is that pre-service teachers' knowledge about and perceived usefulness of evolution are moderately correlated. Also, pre-service teachers' understanding of social expectations regarding the teaching of evolution (the subjective norm) turned out to be a predictor not only of behavioral intention but also of the attitudes toward teaching evolution. In their study—based on a sound psychological theory—the authors provide strong evidence that educational programs that are aimed to increase knowledge about the usefulness of evolution are definitely needed. Beyond this, the study provides information on relevant levers of teacher preparation.

In their qualitative-reconstructive case study, Steinwachs and Martens (2022) investigate the professional vision practices of preservice and in-service biology teachers regarding students' conceptions about evolution when teaching for evolution literacy. Professional vision refers to the ability of teachers to quickly notice information in class and professionally interpret this information immediately. A prominent aim of teacher education is the development of professional vision regarding students' conceptions. With their study, the authors intend to elucidate how professional vision

of preservice and in-service biology teachers regarding students' conceptions and dealing with them in evolution class is practiced. Using a video clip as a prompt, they conducted group discussions and interviews with pre- and in-service teachers. The results show that students' conceptions about evolution often are constructed by pre- and in-service teachers as indicators of subject-specific knowledge gaps that need to be filled or as a problem of teaching in the sense that they are something that must be removed or changed. From their findings the authors conclude that the discussion and reflection of professional vision practices is an important task for teacher education. They argue that using lesson videos and a particular professional development program ("Video Clubs") might offer an opportunity to improve prospective biology teachers' professional vision abilities regarding students' conceptions about evolution.

With the collection of these six papers, we hope that this special issue will inform and help inspire further research and practice into the vitally important area of teacher preparation to teach evolution for evolution literacy as well as for evolutionary literacy.

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