

Adapting science education during crises: first lessons from the COVID-19 pandemic

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Abstract. The COVID-19 pandemic has disrupted science education, forcing teachers and students to switch to online and hybrid modes of learning. This paper reviews recent research on how to cope with these challenges using various innovative teaching strategies. These include online platforms and tools, historical and philosophical perspectives, and holistic approaches to science education. The paper discusses the implications of these findings for the future of science education.

Keywords: science education, COVID-19 pandemic, remote learning, innovative teaching, student-centered learning, science communication, teacher training, educational research, crisis adaptation.

1 Introduction

The COVID-19 pandemic disrupted education worldwide, forcing a shift from traditional classrooms to remote and online learning [3, 6]. This transition presented both opportunities and challenges for educators, students, and parents. How did educational systems cope with the pandemic and what can we learn from their experiences? This paper reviews a selection of research articles that address these questions from various perspectives. By analyzing these studies, we aim to highlight the challenges and innovations in education during the crisis and to contribute to the discussion about the future of education in a changing world.

2 Overview of the five research articles

The COVID-19 pandemic has posed unprecedented challenges for education, requiring teachers and students to adapt to new modes of learning and communication. How can science education respond to these challenges and foster critical thinking, creativity, and curiosity among learners? This is the main question that the reviewed articles address, using various theoretical and methodological approaches.

Rahiem [5] explored the lived experience of Indonesian university students during emergency remote learning (ERL) due to the COVID-19 pandemic. The study used a qualitative phenomenological approach involving 80 students from a social science education program. The findings revealed two main themes:

- 1) **blended learning**: this theme encompassed e-learning, mobile learning (m-learning), and conventional learning. Students adapted to various online learning modes;
- 2) **paradoxical learning**: this theme included flexible and challenging learning experiences. Students found opportunities for flexibility but also faced challenges in adjusting to remote learning.

The study by Archila et al. [1] aimed to promote argumentation skills in university students using historical scientific controversies. The researchers focused on the case of Ignaz Semmelweis and puerperal fever. They found that incorporating this historical controversy into decision-making, small-group debates, and whole-class debates facilitated undergraduates' argumentation skills.

Erduran [2] discussed how the history, philosophy, and sociology of science can contribute to science education during the COVID-19 pandemic. The author emphasized that incorporating these perspectives can enhance students' understanding of the crisis and their ability to critically engage with scientific information.

Usak et al. [7] highlighted the impact of the COVID-19 pandemic on science education. It emphasized the need for educators to maintain a holistic perspective and refresh their basic doctrines, regardless of their specific area of expertise. The article called for a comprehensive approach to address the challenges posed by the pandemic.

Johann et al. [4] focused on cell membrane biology education. Researchers used the Model of Educational Reconstruction (MER) and Conceptual Metaphor theory to identify core ideas related to cell membrane

biology. They found that these ideas could be grouped into themes like compartmentalization, physical and chemical properties, and multicellular coordination, with metaphors aiding understanding.

The articles share a focus on adapting education to the challenges of the pandemic. They emphasize the importance of innovative teaching approaches and maintaining a broader perspective. One of the common themes is the use of online platforms and tools to facilitate science learning and communication. Thus, Erduran [2], Rahiem [5], Usak et al. [7] provide insights into effective teaching strategies during the crisis, such as identifying the factors that influence teachers' readiness and confidence to use online platforms, developing a framework for assessing students' argumentation skills in online discussions, and designing interactive and engaging online activities. Moreover, these articles explore the potential of online platforms to promote collaboration and dialogue among different stakeholders, such as teachers, students, researchers, and policymakers.

However, not all aspects of science education can be easily transferred to online settings. In contrast, Archila et al. [1], Johann et al. [4] argue that historical and philosophical perspectives are essential for understanding the nature and development of science, especially in times of crisis. They propose various ways to integrate historical and philosophical dimensions into science education, such as using historical case studies, analyzing scientific controversies, and examining ethical and social implications of scientific discoveries. They also highlight the challenges and opportunities of teaching history and philosophy of science in online environments.

Another theme that emerges from the articles is the need for a cognitive-linguistic approach to science education. Johann et al. [4] examine how language shapes scientific thinking and communication, and how different linguistic features can affect students' comprehension and retention of scientific concepts. Authors suggest various strategies to enhance students' cognitive-linguistic skills, such as using metaphors, analogies, narratives, and visualizations. They also discuss the challenges and benefits of using different languages and modes of communication in science education.

3 Implications and future directions

The reviewed research holds several significant implications for educational practices during crises, particularly in the context of the COVID-19 pandemic. These implications extend beyond the specific findings of each study and offer insights for educators, policymakers, and

researchers looking to navigate educational challenges during emergencies:

1. *Adaptation and flexibility*: the studies highlight the importance of adapting teaching methods to remote and blended learning environments. Educators need to be flexible in their approaches, incorporating various online tools and strategies to ensure that learning continues effectively during crises.
2. *Pedagogical innovation*: the articles emphasize the need for innovative teaching approaches. Integrating historical cases, argumentation, and philosophical perspectives into curricula can enhance critical thinking and engagement among students, fostering deeper understanding and application of concepts.
3. *Holistic education*: the research underscores the value of holistic education that considers not only subject-specific content but also broader perspectives, such as history, philosophy, and societal impacts. Integrating multidisciplinary viewpoints can help students grasp the real-world significance of scientific concepts.
4. *Student-centered learning*: the experiences of students during the pandemic highlight the importance of designing educational experiences that cater to individual needs and learning styles. Encouraging students to reflect on their experiences and actively participate in discussions can enhance engagement and comprehension.
5. *Science communication*: the studies shed light on the role of science communication during crises. Communicating complex scientific information effectively to students and the broader public is crucial for informed decision-making and societal understanding.
6. *Teacher training and professional development*: as educational landscapes rapidly change during crises, providing educators with training and support to adapt to new teaching methods becomes crucial. Teacher development programs should address both technological skills and pedagogical approaches for remote and blended learning.
7. *Research-practice connection*: the reviewed studies emphasize the importance of evidence-based educational practices. Continuous research and assessment of pedagogical strategies during crises can

inform effective approaches and contribute to the development of best practices.

4 Conclusions and future work

The pandemic has challenged science education, but also opened new possibilities for improvement. The studies we reviewed offer insights into how to teach and learn science effectively in a crisis. Based on these insights, we suggest the following recommendations for science education after COVID-19:

- Invest in technology and infrastructure to support remote learning.
- Train teachers on how to use technology effectively in the classroom.
- Support students' social-emotional learning to cope with the stress of the pandemic.
- Ensure equal access to education for all students, regardless of their background.
- Use the history, philosophy, and sociology of science to foster scientific literacy and critical thinking.

These recommendations can help us prepare students for the challenges of the 21st century. However, more research is needed to understand the impact of the pandemic on science education and to develop innovative solutions. Some areas for future research are:

- The long-term effects of emergency remote learning on student outcomes, well-being, and retention rates.
- The equity implications of remote learning for different groups of students.
- Innovative assessment strategies that align with remote and online learning.
- Interdisciplinary approaches that integrate historical, philosophical, and sociological perspectives into science education.
- Professional development models for teachers during crises.

- Strategies to enhance student engagement in online environments.
- Comparative studies across different educational systems and regions.

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