Challenges in Physics Education

This book series covers various aspects of physics teaching and learning across all educational levels and learning environments. The individual volumes cover a wide array of topics, including innovative approaches and pedagogical strategies for physics education, the development of effective methods to integrate multimedia into physics teaching and learning, pioneering lab experiments, and the utilization of web-based interactive activities. Selected research-based contributions will be prominently featured throughout.

The GIREP, the International Research Group on Physics Teaching, collaborates on this publication series, incorporating selected papers from globally recognized experts and monographs. Book proposals from other sources are also encouraged.

"Challenges in Physics Education" is targeted towards professionals, teachers, researchers, instructors, and curriculum developers, aiming to enhance physics teaching and learning and, consequently, the overall perception of physics within society.

Proposals for publication should be submitted to Marina Forlizzi (marina.forlizzi@springer.com).

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Teaching and Learning Physics Effectively in Challenging Times

Springer

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Preface

The peer-reviewed book presents selected papers from the international conference—GIREP Conference 2022, Ljubljana, Slovenia.

The aim of the book is to familiarize readers with the discussion on physics education related to effective learning in physics, from contemporary physics to remote settings. The book is aimed at a wide range of readers, researchers in the field of physics education, university teachers, physics teachers at various levels of education and other interested parties.

The GIREP Conference 2022 of the International Research Group on Physics Teaching (GIREP, https://www.girep.org/) was organized by the University of Ljubljana, Faculty of Education and Faculty of Mathematics and Physics. It is one of a series of GIREP conferences that have been organized at regular intervals since 1966. The conference took place between 4 and 8 July 2022 in Ljubljana, Faculty of Education.

The main role in the organizing and supervising conference had the following members of the local organizing committee Sergej Faletič, Saša Ziherl, Katarina Susman, Anja Kranjc Horvat and Jerneja Pavlin in collaboration with other members of the local organizing committee and in scientific cooperation with the international advisory board. The event was financially sponsored by GIREP. The conference was attended by 204 participants from 37 countries from around the world.

The conference was organized in a hybrid form after 2 years of webinars. The majority of participants were present live. The presentations of the online participants were integrated into the regular sessions to allow for live feedback, comments, questions and answers.

A central theme of the conference was effective learning in physics from contemporary physics to remote settings. The aim was also to discuss the possibilities of contemporary topics to increase interest, context and scientific literacy in the context of modern technology, combined with the challenges and opportunities of distance teaching and learning. The conference programme enabled the discussion of various topics on contemporary physics, distance education and current aspects of research and practice in physics education.

The programme of the scientific conference offered plenary talks, parallel oral sessions, symposia, workshops and poster sessions. In total, 7 invited talks, 81 oral and 80 poster presentations were held. The conference categorized the contributions into nine categories:

1. Invited Talks: Plenary speakers invited to share their lifelong experience on teaching and learning.
2. Strategies and Methods to Improve Physics Learning and Teaching: From good practices to new tested approaches.
3. Physics Curriculum Materials: Development, Implementation, and Assessment: From the development of new materials to effective teaching of existing topics.
4. Lab work and Experiments in Physics Education: From productive use of experiments in learning and teaching to integrating laboratories and lessons.
5. Contemporary Physics and Modern Physics in School: From non-traditional topics to new approaches in learning and teaching modern physics topics.
6. Teaching and Learning in Remote Settings: From good practices to new findings that emerged during the time of the pandemic.
7. Informal Learning and Non-Formal Learning of Physics: From science centres and outreach to learning from everyday experience
8. Physics Teacher Education: From preparing future physics teachers to building physics teacher community.
9. Students' Identity and Wellbeing as Learners of Physics: From diversity, inclusion, and equity to special needs and gifted students.

The conference was a unique opportunity to provide most participants with an international space for a lively exchange of scientific ideas and best practice, to stimulate new research and projects, to network and to make new contacts for collaboration in physics education.

After the conference, the Local Organizing Committee received 86 submissions, which were subjected to a rigorous process of double-blind peer-review, many of which were of very high quality. Due to the diversity of the proposals and the wealth of topics suggested by the authors, the selection had to be made very carefully. The result was two publications—the Conference Proceedings published in the Journal of Physics: Conference Series and the Springer book in front of you entitled Effective teaching and learning of physics in challenging times. The book you are currently reading contains 21 contributions that were rated as particularly high quality and also includes the contributions of some invited speakers.

The content of the book in front of you is divided into five chapters:

- Lessons from experience.
- General aspects of effective teaching and learning.
- Experience-based teaching and learning.
- Contemporary and complex topics.
- Teacher education.

In the "Lessons from Experience" part, three contributions from selected plenary speakers are collected. These represent an overview of the plenary speakers' research

and provide some background in three areas of physics education research. The first explores the study of learning through inquiry, not just for students but also for teachers. The second uses the example of wave optics to discuss the challenges associated with learning a topic, instruments to assess these challenges and suggests guidelines for addressing them. The third contribution addresses the study and importance of embodied cognition. Students sometimes do not know how to express themselves with words, but they may be able to show correct understanding of concepts with non-verbal communication, such as gestures and movements.

The part entitled "General Aspects of Effective Teaching and Learning" contains five contributions, which address topics of general interest for effective learning of physics. The first contribution is a summary of a symposium on recent developments in physics education research and innovative approaches to teaching and learning in the twenty-first century. The second proposes using human-centred design frameworks to engage students more effectively with the teaching materials. The third proposes teaching physics in the way that physicists do physics. The fourth and fifth address the role of self-efficacy assessments in learning practices, and the importance of a growth mindset for effective learning.

The third part, "Experience-Based Teaching and Learning," focuses on teaching and learning through experience. It comprises five contributions. These include a series of engaging activities with an evaluation for teaching physics in a swimming pool, a contribution focusing on inquiry-based tasks and online learning scenarios, along with their evaluation, and a presentation of laboratory exercises in mechanics using Arduino and smartphones, accompanied by an evaluation of these exercises. The fourth contribution addresses the connection between physics and mathematics and identifies students' difficulties in these areas. The final contribution describes a specific learning experience using game-based learning.

The "Contemporary and Complex Topics" part includes four contributions and addresses topics that may not be in all secondary school curricula but are increasingly important in present times. These include teaching quantum physics due to the increasing role of quantum technology, teaching climate change topics and an example of teaching a topic that students perceive as complex: electrical circuits in primary school.

The last part "Teacher Education" contains four contributions. They deal with the interplay between curricular knowledge and the perceived agency of pre-service physics teachers, the discovery of the relationship between teachers' self-efficacy and the teaching of physics, the interpretation of and reactions to students' explanations, and the development of a training programme for thermodynamics.

We would also like to thank the Scientific Advisory Board and the GIREP Board for the productive discussions and help in preparing the conference and its publications. The organizers would like to thank the authors for their enthusiasm and preparation of the manuscripts and the reviewers for their diligent work and the time they devoted to the evaluation process.

We anticipate that this book will make an important contribution to the development of physics education by providing insights into the various research and initiatives in this area. It is also intended to contribute to advances in the teaching and learning of physics and to address current challenges at different levels of education.

Ljubljana, Slovenia

Sergej Faletič
Jerneja Pavlin

About This Book

This book presents a selection of the best papers from the GIREP Conference 2022, the conference of the International Research Group on Physics Teaching (GIREP).

It introduces readers interested in the field of physics education after the COVID pandemic and discusses the content related to effective learning in physics from contemporary physics to remote areas.

Specifically, the conference covered different areas of physics education: from best practices to new tested approaches, from non-traditional topics to new approaches to learning and teaching modern physics topics, from best practices to new insights that have emerged during the time of the pandemic, from developing new materials to teaching existing topics effectively, from the productive use of experiments in learning and teaching to the integration of labs, from diversity, inclusion and equity to special needs and gifted students, from preparing future physics teachers to building a community of physics teachers, and from science centres and outreach to learning from everyday experiences.

The conference provided an opportunity for in-depth discussion on the above and other areas of physics education. Selected papers covering the above areas in some extents are included in this book.

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