
Encyclopedia of Mathematics Education



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Editor

Encyclopedia of Mathematics Education

With 67 Figures and 9 Tables

 Springer Reference

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Foreword

Two millennia ago, encyclopedias, beginning with that of Pliny the Elder, were the work of one person. Single authors remained the rule for almost 18 centuries until the Enlightenment, when Denis Diderot and Jean d’Alembert assembled dozens of writers to produce their encyclopedia. These days, encyclopedias must rely on hundreds of contributors if they are to provide a reasonably full treatment – even if they are restricted to a single field. No one individual could possibly construct an all-inclusive encyclopedia today. If some group had attempted to produce an encyclopedia of mathematics education a century ago, the tome would necessarily have been fairly meager. Mathematics education was just getting started as a scholarly field and, in most countries, was not present in the academy. Over the following decades, however, the field has continued to grow rapidly, and its literature has become substantial. A search of the scholarly literature on the Web using the term *mathematics education* yielded 129,000 hits in 2008 and 287,000 in 2013 – more than doubling in only 5 years.

The present encyclopedia offers an up-to-date, wide-ranging reference source spanning a field that is growing and in continuing flux. The ambition of the encyclopedia is to deal with every topic in mathematics education, delineating theoretical positions, describing research findings, and citing relevant literature. The length of an entry is tailored to its importance in the field as determined by the editor in chief and his distinguished international editorial board. The publication has three formats: a printed work in one volume, an e-book and an online work that is searchable and will be updated. The printed format will be usable everywhere, including locations without online access; the online work will make the reference comparable to other online encyclopedias, offering opportunities not simply for readers to search the text but also for contributors to add new entries and revise old ones.

Novice mathematics educators will find that the encyclopedia provides a panoramic view of the field, introducing them to whole realms of work they may never have encountered. Old-timers will find entries by giants in the field as well as by contributors from outside the usual circles. Whatever the topic, every reader will find valuable information, including citations of prominent publications. Researchers undertaking a study in mathematics education will want to check first with this reference source to get not only pertinent

theoretical analyses of the topic and relevant research but also a sense of recent controversies and open questions. This encyclopedia represents a major step forward in the field of mathematics education, bringing to everyone with a professional interest in mathematics education access to the latest and best thinking in the field. It is the most timely, comprehensive, and useful reference we have.

Jeremy Kilpatrick

Preface

The encyclopedia is intended to be a comprehensive reference text, covering every topic in the field of mathematics education research with entries ranging from short descriptions to much longer ones where the topic warrants more elaboration. The entries have been written by leaders in the field as a whole, and in most cases they are originators and innovators in the specific entry topic.

The entries provide access to theories and to research in the area and refer to some of the key publications for further reading, including the core texts as well as cutting-edge research, and point also to future developments. We have tried to be comprehensive in terms of drawing on work from around the world, particularly through the knowledge and experience of the section editors. The vast majority of the hard work of soliciting, encouraging, and editing has been carried out by these editors. The list of entries was mapped out at an intensive seminar of the editors, in sections of common theme. Each editor took on responsibility for a theme according to their interests and expertise. They then worked with all the authors to develop and edit the entries in their section. As things progressed, while some editors were overloaded with work, others took on part of their tasks. They have been exemplary in their roles, and an enormous debt of gratitude is owed to them.

Michèle Artigue took responsibility for the section on research on mathematics curriculum topics and Information and Communication in education; Ruhama Even, for research on teaching; Mellony Graven, for research on teacher education; Eva Jablonka, for research on mathematics in out-of-school contexts and for research methods, paradigms, and sociological perspectives; Robyn Jorgensen, for research on curriculum, assessment, and evaluation; Yoshinori Shimizu, for research on learning; and Bharath Sriraman, for research on the nature of mathematics and mathematical thinking and theories of learning.

We have been supported by the excellent team at Springer, including Michael Hermann, Daniela Graf, Clifford Nwaeburu, and Jutta Jaeger-Hamers. The SpringerReference system has been modified and developed in part by the suggestions and needs of the section editors, and credit must go to the developers for making those modifications. In the years to come, I am sure further changes will be needed.

The encyclopedia should be informative for graduate students, researchers, curriculum developers, policy makers, and others with interests in the field of mathematics education. It can be used to support students in

their review of literature and in finding the sources of knowledge in the field. It is our hope, too, that it will enable researchers to connect their research with what has gone before. Too frequently, we see research that either has largely been done before or does not take the opportunity to build on prior work and develop it, but repeats it. Furthermore, we hope that it will support researchers in making links between theoretical approaches and frameworks and the ways they carry out their research, their methodology, and methods. As experts in the field, the entry authors exemplify how these connections should be made, in their descriptions and in the references they provide.

In this first iteration of the encyclopedia, we have not succeeded fully in our goal of being comprehensive. Some entries were not completed in time, potential authors withdrew at the last minute, but on a more positive note colleagues around the world have already indicated topics that should be included in the future. This is not an open access encyclopedia. We welcome and encourage comments, suggestions, critique, and further ideas, which can be made on the particular entry pages. They will be reviewed and considered by the entry authors, and we will periodically invite the authors to make changes in their entry as they see fit, in communication with the editors.

We look forward, also, to reactions to me, editor-in-chief, about what works and what does not, in more general terms, and we will do our best to respond. Recently, we have celebrated 100 years of the international mathematics education community, and we have seen a proliferation of research orientations, journals, and conferences and the growth of research communities around the world. If this venture contributes in substantial ways to these developments, we will be very satisfied that the work has been worthwhile.

Stephen Lerman

About the Editors

Stephen Lerman was a secondary teacher of mathematics in the United Kingdom and Israel for many years and then became Head of mathematics in a London comprehensive school before completing a PhD and moving into mathematics teacher education and research. He was temporary lecturer at the Institute of Education, University of London, and at the University of North London before taking up a permanent position at what is now called London South Bank University. He is a former President of the International Group for the Psychology of Mathematics Education (PME) and Chair of the British Society for Research into Learning Mathematics (BSRLM). He is now Emeritus Professor at London South Bank University, part-time Professor at Loughborough University, Visiting Professor at the University of the Witwatersrand, and Adjunct Professor at Griffith University. His research interests are in sociocultural and sociological theories in mathematics education research and in the use of theories in general in the field.

Bharath Sriraman is Professor of mathematics at the University of Montana and on the Faculty and Advisory Board of Central/SW Asian Studies, where he occasionally offers courses on Indo-Iranian studies/languages. He holds degrees from Alaska (BS in mathematics, University of Alaska–Fairbanks) and Northern Illinois (MS and PhD in mathematics, minor in mathematics education). He maintains active interests in mathematics education, philosophy, history of mathematics, gifted education, and creativity. He has published over 300 journal articles, commentaries, book chapters, edited books, and reviews in his areas of interest and presented more than 200 papers at international conferences, symposia, and invited colloquia. Bharath is the founding editor of *The Mathematics Enthusiast* and the founding co-series editor of *Advances in Mathematics Education* (Springer Science) and of four other book series. He serves on the editorial panel of a dozen or so journals, including *Roeper Review*, *Gifted Child Quarterly*, and *High Ability Studies*. Bharath is fairly fluent in seven to nine languages (English, German, Farsi, Hindi, Tamil, Urdu, Kannada, basic French, and Danish) and travels/holds active ties with researchers all over the world. He received the 2002 NAGC Outstanding Brief of the Year Award; was nominated for the 2006, 2007 NAGC Early Career Scholar Award; and was named the 2007 Outstanding Early Scholar by the School Science and Mathematics Association, and in 2009, Northern Illinois University named him as one of 50 “golden alumni” in the last 50 years for his significant contributions to research in mathematics

education, gifted education, and interdisciplinary research at the intersection of mathematics–science–arts.

Eva Jablonka holds a Chair in mathematics education at King’s College, London, UK. Before joining King’s, she held a range of academic positions in different countries and contexts, including Sweden, Germany, and Australia. Her research includes the study of school mathematics curricula at macro and micro levels (in particular, mathematical modeling and mathematical literacy), the sociology of mathematics, the role of theorizing in mathematics education, cross-cultural comparative studies of mathematics education, and students in transition between different sectors of mathematics education with a focus on the emerging achievement disparities related to these transitions.

Yoshinori Shimizu is a Professor of mathematics education at the Graduate School of Comprehensive Human Sciences, University of Tsukuba, in Japan. His primary research interests include international comparative study on mathematics classrooms and student assessment. He was a member of the Mathematics Expert Group for OECD/PISA 2003, 2006, and 2009. He is one of the founders of Learner’s Perspective Study (LPS), a 16 countries’ comparative study on mathematics classrooms, and has been the Japanese team leader of the project. He serves as a member of editorial boards on international research journals, such as *International Journal of Science and Mathematics Education* and *ZDM-International Journal of Mathematics Education*.

Michèle Artigue is Emeritus Professor at the Paris Diderot University – Paris 7. After completing a PhD in mathematical logic, she progressively moved to the field of mathematics education. In that field, beyond theoretical contributions on the relationships between epistemology and didactics, didactical engineering, the reproducibility of didactic situations, the instrumental approach, and more recently the networking of theoretical frameworks, her main research areas have been the teaching and learning of mathematics at the university level, especially the didactics of calculus and elementary analysis, and the use of digital technologies in mathematics education. She has many editorial and scientific responsibilities at national and international levels, and after being from 1998 to 2006 Vice President of the International Commission on Mathematical Instruction (ICMI), she was its President from 2007 to 2010.

Ruhama Even is Full Professor at the Weizmann Institute of Science and holds the Rudy Bruner Chair of Science Teaching. Her main research and development work is structured around three main interrelated foci: (a) the professional education and development of mathematics teachers, (b) mathematics curriculum development and analysis, and (c) the interplay of factors involved in shaping students’ opportunities to learn mathematics. She has been member of the International Committee of PME and Cochair of ICMI Study 15 on the professional education and development of teachers of mathematics and serves as an editorial board member of the *Journal of*

Mathematics Teacher Education (JMTE) and *Mathematics Education Research Journal (MERJ)*.

Robyn Jorgensen has been working in the area of mathematics education since undertaking her honors and doctoral work at Deakin University. She has focused her work in the area of equity, particularly focusing on the social practices that contribute to the patterns of success (or not) of social, cultural, and linguistic groups. Her strong interest in equity has been in the areas of social class, Indigenous, and issues around language and culture. She has international recognition for her work in this area as evidenced by numerous invitations for keynote addresses; state, national, and international panels; and invited publications and submissions. In 2008 she was invited co-convenor of the ICMI Centenary Conference for the social context working group; in 2008–2009, she was a member of the Ministerial Advisory Committee for Science, Technology, Engineering and Mathematics (STEM) as well as Chair of the Queensland Studies Authority Mathematics Advisory Committee. From 2009, she has been serving as the eminent mathematics education Professor on the national project (Turn the Page) of the Australian Association of Mathematics Teachers for enhancing mathematics learning for Indigenous Australians. She has worked in an advisory capacity for state projects and innovations in various states including Queensland, South Australia, and the Northern Territory. In 2009–2010, she took leave from the university to work as CEO/Principal of an Aboriginal corporation in Central Australia.

Robyn has secured numerous competitive grants including eight Australian Research Grants since 2001. Each grant has had a strong equity dimension to it. Collectively these have spanned the range of learning contexts from early childhood through to workplace learning. She has a critical edge to her work where she seeks to identify and redress issues of inequality in participation, access, and success in mathematics learning and teaching. Her work focuses strongly on practice – whether in formal school settings or settings beyond the school. The work seeks to challenge the status quo that has been implicated in the construction of unequal outcomes for particular groups of people. Her most recent ARC grants indicate the culmination of her challenge to contemporary practices in mathematics education. The work in the Kimberley region is an example of reforming teaching so as to enable Indigenous students greater access to mathematics learning. The newest ARC grant seeks to draw on the impact of digital technologies on young people's mathematical thinking. This project may provide explanations for new numeracies that have been observed in other ARC projects where older adolescents were found to have different dispositions to using and undertaking numeracy than their employers and teachers. These two projects will offer considerable challenges to current practices in school mathematics that are known to have profound (and negative) implications for many disadvantaged groups in Australia and internationally. Robyn is currently working on a 4 year longitudinal study to investigate the effects of early years swimming in under-5s on their development.

Robyn's work seeks to impact on the practices of the various sectors within which she works – whether schools, workplaces, or policy. This can be seen in the ways in which her research is undertaken with a range of industry partners for whom the research is most relevant. In most cases, the industries are actively involved in the studies and use the outcomes to inform their own practice. She is frequently sought by various stakeholders – schools, community groups, industry, policy, state authorities – to provide input into their activities including reports, professional development work, and advice on reform. The work that Robyn has undertaken has been recognized internationally and nationally. She is active in reviewing for a wide range of mathematics education and general education journals, being as well an Oz reviewer for the ARC and a reviewer for national research council grants including for Israel and South Africa. She is currently chief editor of the *Mathematics Education Research Journal* and serves on the editorial board of the *International Journal for Science and Mathematics Education*.

Mellony Graven is the South African Chair of Numeracy Education, Rhodes University. Her work as Chair involves the creation of a hub of mathematical activity, passion, and innovation that blends teacher and learner numeracy development with research focused on searching for sustainable ways forward to the challenges of mathematics education. She is the President of the Southern African Association for Research in Mathematics, Science and Technology Education and past editor of the journal *Learning and Teaching Mathematics*.

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