

HANDBOOK OF

RESEARCH  
DESIGN IN  
MATHEMATICS  
AND SCIENCE  
EDUCATION

EDITED BY

ANTHONY E. KELLY • RICHARD A. LESH

# Handbook Of Research Design In Mathematics And Science Education

**Anthony Edward Kelly, Richard A. Lesh**



## **Handbook Of Research Design In Mathematics And Science Education:**

*Handbook of Research Design in Mathematics and Science Education* Anthony Edward Kelly, Richard A. Lesh, 2012-10-12

The Handbook of Research Design in Mathematics and Science Education is based on results from an NSF supported project REC 9450510 aimed at clarifying the nature of principles that govern the effective use of emerging new research designs in mathematics and science education. A primary goal is to describe several of the most important types of research designs that have been pioneered recently by mathematics and science educators. These designs have distinctive characteristics when they are used in projects that focus on mathematics and science education and have proven to be especially productive for investigating the kinds of complex interacting and adapting systems that underlie the development of mathematics or science students and teachers or for the development, dissemination and implementation of innovative programs of mathematics or science instruction. The volume emphasizes research designs that are intended to radically increase the relevance of research to practice, often by involving practitioners in the identification and formulation of the problems to be addressed or in other key roles in the research process. Examples of such research designs include teaching experiments, clinical interviews, analyses of videotapes, action research, studies, ethnographic observations, software development studies or curricula development studies, more generally, and computer modeling studies. This book's second goal is to begin discussions about the nature of appropriate and productive criteria for assessing and increasing the quality of research proposals, projects or publications that are based on the preceding kind of research designs. A final objective is to describe such guidelines in forms that will be useful to graduate students and others who are novices to the fields of mathematics or science education research. The NSF supported project from which this book developed involved a series of mini-conferences in which leading researchers in mathematics and science education developed detailed specifications for the book and planned and revised chapters to be included. Chapters were also field tested and revised during a series of doctoral research seminars that were sponsored by the University of Wisconsin's OERI supported National Center for Improving Student Learning and Achievement in Mathematics and Science. In these seminars, computer based videoconferencing and www based discussion groups were used to create interactions in which authors of potential chapters served as guest discussion leaders, responding to questions and comments from doctoral students and faculty members representing more than a dozen leading research universities throughout the USA and abroad. A Web site with additional resource materials related to this book can be found at <http://www.soe.purdue.edu/smsc/lesh>. This internet site includes directions for enrolling in seminars, participating in ongoing discussion groups and submitting or downloading resources which range from videotapes and transcripts to assessment instruments or theory based software to publications or data samples related to the research designs being discussed.

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aimed at clarifying the nature of principles that govern the effective use of emerging new research designs in mathematics and science education A primary goal is to describe several of the most important types of research designs that have been pioneered recently by mathematics and science educators have distinctive characteristics when they are used in projects that focus on mathematics and science education and have proven to be especially productive for investigating the kinds of complex interacting and adapting systems that underlie the development of mathematics or science students and teachers or for the development dissemination and implementation of innovative programs of mathematics or science instruction The volume emphasizes research designs that are intended to radically increase the relevance of research to practice often by involving practitioners in the identification and formulation of the problems to be addressed or in other key roles in the research process Examples of such research designs include teaching experiments clinical interviews analyses of videotapes action research studies ethnographic observations software development studies or curricula development studies more generally and computer modeling studies This book s second goal is to begin discussions about the nature of appropriate and productive criteria for assessing and increasing the quality of research proposals projects or publications that are based on the preceding kind of research designs A final objective is to describe such guidelines in forms that will be useful to graduate students and others who are novices to the fields of mathematics or science education research The NSF supported project from which this book developed involved a series of mini conferences in which leading researchers in mathematics and science education developed detailed specifications for the book and planned and revised chapters to be included Chapters were also field tested and revised during a series of doctoral research seminars that were sponsored by the University of Wisconsin s OERI supported National Center for Improving Student Learning and Achievement in Mathematics and Science In these seminars computer based videoconferencing and www based discussion groups were used to create interactions in which authors of potential chapters served as guest discussion leaders responding to questions and comments from doctoral students and faculty members representing more than a dozen leading research universities throughout the USA and abroad A Web site with additional resource materials related to this book can be found at <http://www.soe.purdue.edu/smsc/lesh> This internet site includes directions for enrolling in seminars participating in ongoing discussion groups and submitting or downloading resources which range from videotapes and transcripts to assessment instruments or theory based software to publications or data samples related to the research designs being discussed

*Handbook of Design Research Methods in Education* Anthony E. Kelly, Richard A. Lesh, John Y. Baek, 2014-07-16 This Handbook presents the latest thinking and current examples of design research in education Design based research involves introducing innovations into real world practices as opposed to constrained laboratory contexts and examining the impact of those designs on the learning process Designed prototype applications e g instructional methods software or materials and the research findings are then cycled back into the next iteration of the design innovation in order to build evidence of the particular theories being researched and to

positively impact practice and the diffusion of the innovation The Handbook of Design Research Methods in Education the defining book for the field fills a need in how to conduct design research by those doing so right now The chapters represent a broad array of interpretations and examples of how today s design researchers conceptualize this emergent methodology across areas as diverse as educational leadership diffusion of innovations complexity theory and curriculum research This volume is designed as a guide for doctoral students early career researchers and cross over researchers from fields outside of education interested in supporting innovation in educational settings through conducting design research *Handbook of International Research in Mathematics Education* Lyn D. English, David Kirshner, 2010-04-02 The second edition continues the mission of bringing together important new mathematics education research that makes a difference in both theory and practice It updates and extends the Handbook s original key themes and issues for international research in mathematics education for the 21st century namely priorities in international mathematics education research lifelong democratic access to powerful mathematical ideas advances in research methodologies influences of advanced technologies Each of these themes is examined in terms of learners teachers and learning contexts with theory development being an important component of all these aspects This edition also examines other catalysts that have gained increased import in recent years including a stronger focus on the teacher and teacher practice a renewed interest in theory development an increased focus on the mathematics needed in work place settings and a proliferation of research designs and methodologies that have provided unprecedented opportunities for investigating and ultimately improving mathematical teaching and learning This edition includes ten totally new chapters all other chapters are thoroughly revised and updated Mathematics Education and the Legacy of Zoltan Paul Dienes Bharath Sriraman, 2008-03-01 The name of Zoltan P Dienes 1916 stands with those of Jean Piaget and Jerome Bruner as a legendary figure whose theories of learning have left a lasting impression on the field of mathematics education Dienes name is synonymous with the Multi base blocks also known as Dienes blocks which he invented for the teaching of place value He also is the inventor of Algebraic materials and logic blocks which sowed the seeds of contemporary uses of manipulative materials in mathematics instruction Dienes place is unique in the field of mathematics education because of his theories on how mathematical structures can be taught from the early grades onwards using multiple embodiments through manipulatives games stories and dance Dienes notion of embodied knowledge presaged other cognitive scientists who eventually came to recognize the importance of embodied knowledge and situated cognition where knowledge and abilities are organized around experience as much as they are organized around abstractions Dienes was an early pioneer in what was later to be called sociocultural perspectives and democratization of learning This monograph compiled and edited by Bharath Sriraman honors the seminal contributions of Dienes to mathematics education and includes several recent unpublished articles written by Dienes himself These articles exemplify his principles of guided discovery learning and reveal the non trivial mathematical structures that can be made accessible to any student The monograph also

includes a rare interview with Dienes in which he reflects on his life his work the role of context language and technology in mathematics teaching and learning today The book finds an important place in any mathematics education library and is vital reading for mathematics education researchers cognitive scientists prospective teachers graduate students and teachers of mathematics

**Models and Modeling Perspectives** Richard A. Lesh, 2014-07-16 This special issue of Mathematical Thinking and Learning describes models and modeling perspectives toward mathematics problem solving learning and teaching The concern is not only the mature forms of models and modeling in communities of scientists and mathematicians but also the need to initiate students in these forms of thought The contributions of this issue suggest a variety of ways that students children through adults can be introduced to highly productive forms of modeling practices Collectively they illustrate how modeling activities often lead to remarkable mathematical achievements by students formerly judged to be too young or too lacking in ability for such sophisticated and powerful forms of mathematical thinking The papers also illustrate how modeling activities often create productive interdisciplinary niches for mathematical thinking learning and problem solving that involve simulations of similar situations that occur when mathematics is useful beyond school

**Interdisciplinarity, Creativity, and Learning** Bharath Sriraman, Viktor Freiman, Nicole Lirette-Pitre, 2009-06-01 Interdisciplinarity is increasingly viewed as a necessary ingredient in the training of future oriented 21st century disciplines that rely on both analytic and synthetic abilities across disciplines Nearly every curricular document or vision statement of schools and universities include a call for promoting creativity in students Yet the construct of creativity and giftedness across disciplines remains elusive in the sense that the prototypical examples of such work come from eminent scientists artists and mathematicians and little if any work has been conducted with non eminent individuals This monograph is an attempt to fill this gap by putting forth the view that interdisciplinarity and creativity are related constructs and that the cultivation of domain general creativity is possible Mathematics has historically been anchored to numerous disciplines like theology natural philosophy culture and art allowing for a flexibility of thought that is difficult to cultivate in other disciplines In this monograph the numerous chapters from Australia U S A Canada Cyprus Denmark and Japan provide a compelling illustration of the intricate connection of mathematics with literature paradoxes history technology and modeling thus serving as a conduit for interdisciplinarity creativity and learning to occur

**Handbook of Research on Science Education, Volume II** Norman G. Lederman, Sandra K. Abell, 2014-07-11 Building on the foundation set in Volume I a landmark synthesis of research in the field Volume II is a comprehensive state of the art new volume highlighting new and emerging research perspectives The contributors all experts in their research areas represent the international and gender diversity in the science education research community The volume is organized around six themes theory and methods of science education research science learning culture gender and society and science learning science teaching curriculum and assessment in science science teacher education Each chapter presents an integrative review of the research on the topic it addresses pulling together the

existing research working to understand the historical trends and patterns in that body of scholarship describing how the issue is conceptualized within the literature how methods and theories have shaped the outcomes of the research and where the strengths weaknesses and gaps are in the literature Providing guidance to science education faculty and graduate students and leading to new insights and directions for future research the Handbook of Research on Science Education Volume II is an essential resource for the entire science education community Internationalisation and Globalisation in Mathematics and Science Education Bill Atweh,Angela Calabrese Barton,Marcelo C. Borba,Noel Gough,Christine Keitel-Kreidt,Catherine Vistro-Yu,Renuka Vithal,2007-08-28 This book aims to develop theoretical frameworks of the phenomena of internationalisation and globalisation and identify related ethical moral political and economic issues facing mathematics and science educators It provides a wide representation of views some of which are not often represented in international publications This is the first book to deal with issues of globalisation and internationalisation in mathematics and science education Theories of Mathematics Education Bharath Sriraman,Lyn English,2009-10-13 Advances in Mathematics Education is a new and innovative book series published by Springer that builds on the success and the rich history of ZDM The International Journal on Mathematics Education formerly known as Zentralblatt für Mathematik One characteristic of ZDM since its inception in 1969 has been the publication of themed issues that aim to bring the state of the art on central sub domains within mathematics education The published issues include a rich variety of topics and contributions that continue to be of relevance today The newly established monograph series aims to integrate synthesize and extend papers from previously published themed issues of importance today by orienting these issues towards the future state of the art The main idea is to move the field forward with a book series that looks to the future by building on the past by carefully choosing viable ideas that can fruitfully mutate and inspire the next generations Taking inspiration from Henri Poincaré 1854-1912 who said To create consists precisely in not making useless combinations and in making those which are useful and which are only a small minority Science Education in the 21st Century Ingrid V. Eriksson,2008 This is hardly another field in education which is more important for a country's future than science education Yet more and more students elect to concentrate on other fields to the exclusion of science for a variety of reasons 1 The perception of degree of difficulty 2 The actual degree of difficulty 3 The lack of perceived prestige and earnings associated with the field 4 The dearth of good and easy to use texts 5 The lack of society in comprehending the significance of science and creating attractive incentives for those who enter the field This book presents new issues and challenges for the field Encyclopedia of the Sciences of Learning Norbert M. Seel,2011-10-05 Over the past century educational psychologists and researchers have posited many theories to explain how individuals learn i.e. how they acquire organize and deploy knowledge and skills The 20th century can be considered the century of psychology on learning and related fields of interest such as motivation cognition metacognition etc and it is fascinating to see the various mainstreams of learning remembered and forgotten over the 20th century and note

that basic assumptions of early theories survived several paradigm shifts of psychology and epistemology Beyond folk psychology and its naive theories of learning psychological learning theories can be grouped into some basic categories such as behaviorist learning theories connectionist learning theories cognitive learning theories constructivist learning theories and social learning theories Learning theories are not limited to psychology and related fields of interest but rather we can find the topic of learning in various disciplines such as philosophy and epistemology education information science biology and as a result of the emergence of computer technologies especially also in the field of computer sciences and artificial intelligence As a consequence machine learning struck a chord in the 1980s and became an important field of the learning sciences in general As the learning sciences became more specialized and complex the various fields of interest were widely spread and separated from each other as a consequence even presently there is no comprehensive overview of the sciences of learning or the central theoretical concepts and vocabulary on which researchers rely The Encyclopedia of the Sciences of Learning provides an up to date broad and authoritative coverage of the specific terms mostly used in the sciences of learning and its related fields including relevant areas of instruction pedagogy cognitive sciences and especially machine learning and knowledge engineering This modern compendium will be an indispensable source of information for scientists educators engineers and technical staff active in all fields of learning More specifically the Encyclopedia provides fast access to the most relevant theoretical terms provides up to date broad and authoritative coverage of the most important theories within the various fields of the learning sciences and adjacent sciences and communication technologies supplies clear and precise explanations of the theoretical terms cross references to related entries and up to date references to important research and publications The Encyclopedia also contains biographical entries of individuals who have substantially contributed to the sciences of learning the entries are written by a distinguished panel of researchers in the various fields of the learning sciences

**Quantitative Reasoning in Mathematics and Science Education** Gülseren Karagöz Akar, İsmail Özgür Zembat, Selahattin Arslan, Patrick W. Thompson, 2023-01-01 This book focuses on quantitative reasoning as an orienting framework to analyse learning teaching and curriculum in mathematics and science education Quantitative reasoning plays a vital role in learning concepts foundational to arithmetic algebra calculus geometry trigonometry and other ideas in STEM The book draws upon the importance of quantitative reasoning and its crucial role in education It particularly delves into quantitative reasoning related to the learning and teaching diverse mathematics and science concepts conceptual analysis of mathematical and scientific ideas and analysis of school mathematics K 16 curricula in different contexts We believe that it can be considered as a reference book to be used by researchers teacher educators curriculum developers and pre and in service teachers

**Connecting Science and Engineering Education Practices in Meaningful Ways** Leonard A. Annetta, James Minogue, 2016-03-02 The need for a scientifically literate citizenry one that is able to think critically and engage productively in the engineering design process has never been greater By raising engineering design to



the same level as scientific inquiry the Next Generation Science Standards NGSS have signaled their commitment to the integration of engineering design into the fabric of science education This call has raised many critical questions How well do these new standards represent what actually engineers do Where do the deep connections among science and engineering practices lie To what extent can or even should science and engineering practices co exist in formal and informal educational spaces Which of the core science concepts are best to leverage in the pursuit of coherent and compelling integration of engineering practices What science important content may be pushed aside This book tackles many of these tough questions head on All of the contributing authors consider the same core question Given the rapidly changing landscape of science education including the elevated status of engineering design what are the best approaches to the effective integration of the science and engineering practices They answered with rich descriptions of pioneering approaches critical insights and useful practical examples of how embodying a culture of interdisciplinarity and innovation can fuel the development of a scientifically literate citizenry This collection of work builds traversable bridges across diverse research communities and begins to break down long standing disciplinary silos that have historically often hamstrung well meaning efforts to bring research and practice from science and engineering together in meaningful and lasting ways

**The SimCalc Vision and Contributions** Stephen J. Hegedus, Jeremy Roschelle, 2012-12-16 This volume provides essential guidance for transforming mathematics learning in schools through the use of innovative technology pedagogy and curriculum It presents clear rigorous evidence of the impact technology can have in improving students learning of important yet complex mathematical concepts and goes beyond a focus on technology alone to clearly explain how teacher professional development pedagogy curriculum and student participation and identity each play an essential role in transforming mathematics classrooms with technology Further evidence of effectiveness is complemented by insightful case studies of how key factors lead to enhancing learning including the contributions of design research classroom discourse and meaningful assessment The volume organizes over 15 years of sustained research by multiple investigators in different states and countries who together developed an approach called SimCalc that radically transforms how Algebra and Calculus are taught The SimCalc program engages students around simulated motions such as races on a soccer field and builds understanding using visual representations such as graphs and familiar representations such as stories to help students to develop meaning for more abstract mathematical symbols Further the SimCalc program leverages classroom wireless networks to increase participation by all students in doing talking about and reflecting on mathematics Unlike many technology programs SimCalc research shows the benefits of balanced attention to curriculum pedagogy teacher professional development assessment and technology and has proven effectiveness results at the scale of hundreds of schools and classrooms Combining the findings of multiple investigators in one accessible volume reveals the depth and breadth of the research program and engages readers interested in Engaging students in deeply learning the important concepts in mathematics Designing innovative curriculum

software and professional development Effective uses of technology to improve mathematics education Creating integrated systems of teaching that transform mathematics classrooms Scaling up new pedagogies to hundreds of schools and classrooms Conducting research that really matters for the future of mathematics learning Engaging students in deeply learning the important concepts in mathematics Designing innovative curriculum software and professional development Effective uses of technology to improve mathematics education Creating integrated systems of teaching that transform mathematics classrooms Scaling up new pedagogies to hundreds of schools and classrooms Conducting research that really matters for the future of mathematics learning     Modeling Students' Mathematical Modeling Competencies Richard Lesh, Peter L. Galbraith, Christopher R. Haines, Andrew Hurford, 2013-03-17 Modeling Students Mathematical Modeling Competencies offers welcome clarity and focus to the international research and professional community in mathematics science and engineering education as well as those involved in the sciences of teaching and learning these subjects     **The New Science Education Leadership** Jane F. Schielack, Stephanie L. Knight, 2015-04-25 How can we use new technology to support and educate the science leaders of tomorrow This unique book describes the design development and implementation of an effective science leadership program that promotes collaboration among scientists and science educators provides authentic research experiences for educators and facilitates adaptation and evaluation of these experiences for students in secondary and post secondary classrooms The information technology used focuses on visualization simulation modeling and analyses of complex data sets The book also examines program outcomes including analyses of resulting classroom implementation and impacts on science and education faculty graduate students and secondary science teachers and their students Contributors Gillian Acheson Ruth Anderson Lawrence Griffing Bruce Herbert Margaret Hobson Cathleen C Loving Karen McNeal Jim Minstrell George M Nickles Susan Pedersen Carol Stuessy and X Ben Wu     **Measurements in Evaluating Science Education** Amy J. Catalano, Michael A. Marino, 2020-05-06 Measurements in Evaluating Science Education is a comprehensive intuitive guide to many of the key instruments created to assess science education environments learning and instruction Nearly 70 different surveys tests scales and other metrics are organized according to the qualities the measures attempt to gauge such as attitudes toward science beliefs and misconceptions self efficacy and content knowledge Summaries of each instrument usage information developmental history and validation and reported psychometric properties make this an essential reference for anyone interested in understanding science education assessment     *Mathematical Modelling Education in East and West* Frederick Koon Shing Leung, Gloria Ann Stillman, Gabriele Kaiser, Ka Lok Wong, 2021-04-26 This book documents ongoing research and theorizing in the sub field of mathematics education devoted to the teaching and learning of mathematical modelling and applications Mathematical modelling provides a way of conceiving and resolving problems in people s everyday lives as well as sophisticated new problems for society at large Mathematical tradition in China that emphasizes algorithm and computation has now seen a

renaissance in mathematical modelling and applications where China has made significant progress with its economy science and technology In recent decades teaching and learning of mathematical modelling as well as contests in mathematical modelling have been flourishing at different levels of education in China Today teachers and researchers in China become keener to learn from their colleagues from Western countries and other parts of the world in research and teaching of mathematical modelling and applications The book provides a dialogue and communication between colleagues from across the globe with new impetus and resources for mathematical modelling education and its research in both West and East with new ideas on modelling teaching and practices inside and outside classrooms All authors of this book are members of the International Community of Teachers of Mathematical Modelling and Applications ICTMA the peak research body into researching the teaching assessing and learning of mathematical modelling at all levels of education from the early years to tertiary education as well as in the workplace The book is of interest to researchers mathematics educators teacher educators education administrators policy writers curriculum developers professional developers in service teachers and pre service teachers including those interested in mathematical literacy

**Fourth International Handbook of Mathematics Education** M.A. (Ken) Clements, Berinderjeet Kaur, Thomas Lowrie, Vilma Mesa, Johan Prytz, 2024-11-19 This fourth international handbook discusses developments not recognized or dealt with fully in the first three Springer Mathematics Education handbooks and tackles controversial issues in the field After starting with a provocative introductory chapter which asks whether controversy is a healthy feature of international mathematics education the four following sections cover a mathematics education in Asia b the roles of theory in research and practice c equity and social justice and d curriculum and change These themes are taken up in 28 chapters by 60 authoritative authors from all continents Each of the four sections is structured on the basis of past present and future aspects Like the first three mathematics education handbooks this handbook provides a very valuable resource for teachers mathematics education practitioners and researchers education policy makers and mathematicians as well as graduate and undergraduate students

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