

BEATRIZ CHU CLEWELL
BERNICE TAYLOR ANDERSON • MARGARET E. THORPE

BREAKING



THE



BARRIERS

**Helping Female and Minority Students
Succeed in Mathematics and Science**

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Mathematics and Science**



Jossey-Bass Publishers • San Francisco

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Library of Congress Cataloging-in-Publication Data

Clewell, Beatriz C.

Breaking the barriers : helping female and minority students succeed in mathematics and science / Beatriz Chu Clewell, Bernice Taylor Anderson, Margaret E. Thorpe.

p. cm. — (The Jossey-Bass education series)

Includes bibliographical references and index.

ISBN 1-55542-482-1

ISBN 978-1-55542-482-4

1. Mathematics—Study and teaching (Secondary)—United States.
2. Science—Study and teaching (Secondary)—United States.
3. Minority students—Education (Secondary)—United States.
- I. Anderson, Bernice. II. Thorpe, Margaret E. III. Title.
- IV. Series.

QA13.C538 1992

510'.71'273—dc20

92-21619

CIP

FIRST EDITION

HB Printing 10 9 8 7 6 5 4 3 2 1

Code 9282



BREAKING THE BARRIERS

Beatriz Chu Clewell
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***The Jossey-Bass
Education Series***

Preface

The ability of any nation to compete successfully in a global market today depends on the scientific and mathematical literacy of its citizens. In the case of the United States, this literacy has been called into question by the poor showing of U.S. students in mathematics and science assessments in both national and international studies (Dossey, Mullis, Lindquist, and Chambers, 1988; Jones and others, 1992; Lapointe, Askew, and Mead, 1992; Lapointe, Mead, and Askew, 1992; Mullis, Dossey, Owen, and Phillips, 1991; Mullis and Jenkins, 1988). To compound the problem, there has been a decline in the size of the talent pool that feeds mathematics- and science-related positions in industry, education, and government (National Academy of Sciences, 1987; National Research Council, 1989, 1991; Task Force on Women, Minorities, and the Handicapped in Science and Technology, 1988; U.S. Congress, Office of Technology Assessment, 1988a, 1988b). Two recent reports underscore the magnitude of the problem that this book addresses. *The National Education Goals Report* (National Education Goals Panel, 1991) indicates that the United States will be alarmingly short of reaching the president's goal of making the nation's students number one in the world in science and mathematics achievement by the year 2000. A new education report, based on a study conducted by the College Entrance Examination Board and the Western Interstate Commission for Higher Education

(1991), was released a few weeks before the goals report. It predicts that by 1995, one-third of U.S. public school students will be members of minority groups, which have traditionally been underrepresented among math and science professionals.

For the United States to maintain a preeminent position in the world economy, the mathematical and scientific skills of its populace must be upgraded, most likely through educational reform. A concomitant goal should be bringing into parity in math and science achievement the fastest-growing segment of the population (one that has traditionally underachieved in those areas): Black, Hispanic, and Native American citizens. Women, who make up roughly half of the nation's population, are also under-achievers. Intervention programs in mathematics and science for minorities and females provide some effective remedies to enhance achievement and interest of these students in the subjects.

Purpose of the Book

Breaking the Barriers grew out of a need to document the knowledge about intervention programs that we acquired as a result of a project funded by the Ford Foundation. The foundation was ahead of its time in focusing on middle school as a point in the educational process where changes in mathematics and science instruction were crucial; previous, intervention in these subjects had focused on the high school and college years. The foundation commissioned a project to, first, document the range and activities of intervention programs in mathematics, science, and computer science for minority and female students in grades 4 through 8 and, second, identify characteristics and practices of effective programs. The first phase of the project resulted in the publication of a directory that describes 163 intervention programs nationwide, identifies gaps in service delivery, and recommends changes in policy (Clewell, Thorpe, and Anderson, 1987). In this book, we emphasize the findings of the second phase of the project—case studies of effective programs.

Although intervention programs have existed for thirty years, there has not previously been a concerted attempt to bring together what is known about these programs—the range of effective strategies and approaches as well as the structural com-

ponents of effective programs—into a single book. Nor has there been a previous effort to link the most effective strategies utilized by these programs to the theory and empirical research that underlie them or to provide guidelines for establishing programs. This book attempts to do these things—to provide an in-depth examination of the strategies, structure, and operation of intervention programs for minority and female students in grades 4 through 8.

Audience

What we wished to accomplish in writing this book was to produce a handbook on the development and delivery of more effective services to young minority and female students. It is our hope that it will help practitioners, educators, and policy makers to realize the wealth of experience and knowledge that resides in intervention programs and that this realization will lead to an increased emphasis on the institutionalization of effective practices developed by the programs. At a time when the instruction of mathematics and science in our nation's schools is in desperate need of revitalization, we cannot afford to ignore a most valuable resource—intervention programs in mathematics and science.

Because the practices outlined in the book are translatable to the regular classroom setting, our intended audience includes not only directors or would-be directors of intervention programs but also state education agency staff members, professional associations, school district administrators, teachers, math and science coordinators and other curriculum specialists, and foundation staff. We have even included a chapter (Chapter Nine) that discusses the institutionalization of innovative practices and factors that encourage this difficult process, because we feel that these practices, pioneered by intervention programs, can significantly enhance the quality of mathematics and science instruction.

Overview of the Contents

The book is divided into four parts. Parts One and Two focus on barriers to achievement and participation in mathematics and science as well as strategies to overcome these barriers. In Part One, Chapter One discusses the barriers to participation

in mathematics and science and the need for intervention. Chapter Two explains why intervention efforts are needed at the middle school level and describes the changes that can help minority and female students attain proficiency in math and science. In Part Two, Chapters Three and Four describe intervention approaches and strategies, link those approaches to their bases in research and theory, and provide concrete examples of their use in middle school intervention programs.

Parts Three and Four discuss the delivery systems for the strategies and approaches described in Parts One and Two, concentrating on the programmatic aspects of model intervention programs—their structure and implementation. In Part Three, Chapter Five develops a conceptual framework for analyzing programs and describes in detail the key components of an effective program and how they interact, and Chapter Six discusses program outcomes and contextual elements. The three chapters in Part Four present a guide to implementing a program and discuss issues of institutionalization. Chapters Seven and Eight describe the steps that go into planning, developing, and implementing a program; Chapter Nine suggests methods of disseminating program findings and strategies, discusses the problems of institutionalizing innovative practices, and identifies factors that encourage successful institutionalization.

The appendixes following Part Four present case studies of ten effective programs; a directory of successful intervention programs, including useful materials available from them; and a bibliography of research on personal, educational, and social influences on math and science learning.

Acknowledgments

We wish to acknowledge the many individuals who contributed to this book. First, we would like to thank the staff and participants of the ten case-study programs featured in this work for their participation in our interviews and site visits and their reviews of our case studies. Thanks also go to the 163 programs that responded to our request for program information that we included in the study. The research and production of the report

on which this book is based were funded by a grant from the Ford Foundation, although the book's contents do not necessarily reflect the foundation's views. A special acknowledgment is due to our program officer at the Ford Foundation, Barbara Scott Nelson, who recognized the need for this project and provided support and guidance.

Special appreciation goes to Lesley Iura, editor of the Education Series at Jossey-Bass, and Christie Hakim, her editorial assistant, for their encouragement, support, and insightful suggestions during the preparation of this book. We also extend our thanks to Frank Welsch, project editor, who served as our liaison as the manuscript was edited and put into production. In addition to the staff at Jossey-Bass, we would like to thank the anonymous reviewers for their helpful comments. Their constructive criticism contributed to the improvement of our manuscript.

We appreciate the support received from the Educational Testing Service (ETS), especially Margaret Goertz, in this undertaking. We also extend our heartfelt thanks to our colleagues at ETS who were involved in the research, writing, proofreading, and typing that went into this publication: Thelma Benton, Carla Cooper, Rosalea Courtney, Joyce Gant, Jeffrey Marshall, and Mary Evelyn Runyon. We single out Barbara Bruschi for our very special gratitude for the care with which she edited and proofread our manuscript. (The opinions expressed in this book do not necessarily reflect official ETS position or policy.)

Angelica Braestrup, who made available a quiet hideaway (Copperhead Farm) ideal for writing, deserves a special mention.

Finally, we would like to thank our families for their encouragement and support throughout the duration of this project.

Princeton, New Jersey
August 1992

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The Authors

Beatriz Chu Clewell is a senior research scientist in the Division of Education Policy Research at Educational Testing Service. She received her B.A. degree (1970) in English literature and her Ph.D. degree (1980) in educational policy, planning, and analysis, both from Florida State University. Clewell's main research activities have focused on factors that encourage or impede equal access to educational opportunity for minorities and women. She has conducted research on institutional policies and practices that are successful in recruiting and retaining minority students in undergraduate and graduate education. Another area of interest has been intervention programs in science and mathematics and their role in achieving parity for underrepresented minorities and women. She has directed studies of intervention programs at both the middle school and the undergraduate levels. In 1992, she was selected as a Distinguished Scholar by the American Educational Research Association Standing Committee on the Role and Status of Minorities in Educational Research and Development. Clewell's publications include *Women of Color in Mathematics, Science, and Engineering: A Review of the Literature* (1991, with B. T. Anderson), *Building the Nation's Work Force from the Inside Out: Educating Minorities for the Twenty-first Century* (1991, with S. V. Brown), and *Intervention Programs in Math, Science, and Computer Science for Minority and Female Students in Grades Four Through Eight* (1987, with M. E. Thorpe and B. T. Anderson).

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Margaret E. Thorpe is a special education consultant for the New Jersey State Department of Education, Division of Special Education. She trains and provides technical assistance to parents and educators of students with disabilities. She received her B.A. degree (1968) in history, her M.Ed. degree (1973) in special education—early childhood, and her Ed.D. degree (1987) in special education—educational psychology, all from Rutgers University. She worked in the Division for Education Policy Research at Educational Testing Service from 1980 to 1988. Her research activities have included field-based studies of the integration of students with severe disabilities into public schools and the use of technology to promote science learning among high school students. She has also participated in studies of programs and practices affecting mathematics and science learning of middle school minority and female students. Her interests include effective instructional and learning strategies for students with diverse learning styles and abilities. She is coauthor of *Intervention Programs in Math, Science, and Computer Science for Minority and Female Students in Grades Four Through Eight* (1987, with B. C. Clewell and B. T. Anderson).

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PART ONE

Promoting Participation in Mathematics and Science

Recently, there has been increasing concern about the human resource needs of the United States to compete in a global market that relies heavily on technological innovation. There has been a decline in the pool of people equipped to assume mathematics and science positions in industry and education (National Academy of Sciences, 1987; National Research Council, 1991; U.S. Congress, Office of Technology Assessment, 1988a, 1988b; Vetter, 1990). Recent reports have pointed out that the pool of White males trained in these areas is insufficient to provide the number of scientists, engineers, and technicians needed in our society and that there is an urgent need to increase the number of women and minorities in science and engineering (National Science Foundation, 1992; U.S. Congress, Office of Technology Assessment, 1988a, 1988b; Vetter, 1990). This finding appears to be particularly relevant because of the significant increase in the proportion of minority students in the school-age population and the fact that more females are entering the work force.

Part One explores the barriers that minority and female students experience in mathematics and science participation during the middle school years. Chapter One discusses the four barriers to participation in mathematics and science and