

# Core-Plus Mathematics Project

## Evaluation and Research Bibliography

### Peer-Reviewed Journal Publications

Chávez, Ó., Tarr, J. E., Grouws, D. A., & Soria, V. M. (2015, March). Third-year high school mathematics curriculum: Effects of content organization and curriculum implementation. *International Journal of Science and Mathematics Education*. Volume 13, Supplement 1, 97–120.

We examined the effect of curriculum organization in US high schools where students could freely choose to study mathematics from textbooks that employed one of two types of content organization, an integrated approach or a (traditional) subject-specific approach. The study involved 2,242 high school students, enrolled in either Course 3 or Algebra 2, in 10 schools in 5 geographically dispersed states. Taking account of curriculum implementation and students' prior mathematics learning, we analyzed two end-of-year outcome measures: a test of common objectives and a standardized achievement test. Our hierarchical linear models with three levels showed that students in the integrated curriculum scored significantly higher than those in the subject-specific curriculum on the common objectives test. In both outcome measures, gender and prior achievement were significant student-level predictors. In the standardized achievement test, ethnicity was a moderating factor. At the teacher-level, in addition to curriculum type, teachers' orientation and free and reduced lunch eligibility were significant moderating factors. Opportunity to learn, implementation fidelity, teacher experience, and professional development were not significant predictors.

Hong, D. S., & Choi, K. M. (2014). A comparison of Korean and American secondary school textbooks: The case of quadratic equations. *Educational Studies in Mathematics*, 85(2), 241–263.

This study reports a content analysis of the development of quadratic equations in national Korean and *Core-Plus Mathematics* textbooks. The number of topics, contents, and mathematics items were analyzed. The results show that in Korean textbooks some topics are developed relatively earlier than in *Core-Plus Mathematics*. However, the *Core-Plus Mathematics* textbooks include more problems requiring explanations and various representations and problems requiring higher-level cognitive demand.

Tarr, J. E., Grouws, D. A., Chávez, Ó., & Soria, V. M. (2013). The effects of content organization and curriculum implementation on students' mathematics learning in second-year high school courses. *Journal for Research in Mathematics Education*, 44(4), 683–729.

We examined curricular effectiveness in high schools that offered parallel paths in which students were free to study mathematics using one of two content organizational structures: an integrated approach, *Core-Plus Mathematics*, or a (traditional) subject-specific approach (published by Glencoe, Holt, McDougal Littell, or Prentice Hall). The

study involved 3,258 high school students, enrolled in either *Core-Plus Mathematics* Course 2 or Geometry, in 11 schools in 5 geographically dispersed states. We constructed three-level hierarchical linear models of scores on three end-of-year outcome measures: a test of common objectives, an assessment of problem solving and reasoning, and a standardized assessment of conceptual understanding and problem solving. Students in *Core-Plus Mathematics* scored significantly higher than those in the subject-specific curricula on the standardized achievement test. Significant student-level predictors included prior achievement, gender, and ethnicity. At the teacher level, in addition to curriculum type, the opportunity to learn and classroom learning environment factors demonstrated significant power in predicting student scores, whereas implementation fidelity, teacher experience, and professional development were not significant predictors.

Grouws, D. A., Tarr, J. E., Chávez, Ó., Sears, R., Soria, V. M., & Taylan, R. D. (2013). Curriculum and implementation effects on high school students' mathematics learning from curricula representing subject-specific and integrated content organizations. *Journal for Research in Mathematics Education*, 44(2), 416–463.

This study examined the effect of two types of mathematics content organization on high school students' mathematics learning while taking into account curriculum implementation and student prior achievement. Hierarchical linear modeling with three levels showed that students who studied from the integrated curriculum, *Core-Plus Mathematics*, were significantly advantaged over students who studied from subject-specific curricula (published by Glencoe, Holt, McDougal Littell, or Prentice Hall) on three end-of-year outcome measures: Test of Common Objectives, Problem Solving and Reasoning Test, and a standardized achievement test. Opportunity to learn and teaching experience were significant moderating factors.

Dupuis, D. N., Medhanie, A. G., Harwell, M. R., Lebeau, B., & Monson, D. (2012). A multi-institutional study of the relationship between high school mathematics achievement and performance in introductory college statistics. *Statistics Education Research Journal*, 11(1), 4–20.

This study examined the effects of prior mathematics achievement and completion of a commercially developed, National Science Foundation-funded, or University of Chicago School Mathematics Project high school mathematics curriculum on achievement in students' first college statistics course. Specifically, we examined the relationship between students' high school mathematics achievement and high school mathematics curriculum on the difficulty level of students' first college statistics course, and on the grade earned in that course. In general, students with greater prior mathematics achievement took more difficult statistics courses and earned higher grades in those courses. The high school mathematics curriculum a student completed was unrelated to statistics grades and course-taking.

Harwell, M. R., Medhanie, A. G., Post, T. R., Norman, K. W., & Dupuis, D. N. (2012). Preparation of students completing a *Core-Plus* or commercially developed high school mathematics curriculum for intense college mathematics coursework. *Journal of Experimental Education*, 80(1), 96–112.

The purpose of this study was to examine the college mathematics achievement and course-taking patterns of students at a large public research university who completed a commercially developed or standards-based (*Core-Plus Mathematics*) high school mathematics curriculum, and who subsequently completed at least two college mathematics courses of difficulty level at or beyond precalculus mathematics. Mathematics course-taking and achievement data across eight college semesters were analyzed for a sample of 1,588 students. Findings indicated that students (including science, technology, engineering, and mathematics majors) were equally prepared for intense college mathematics coursework regardless of which high school mathematics curriculum they completed. These findings inform high school mathematics curriculum adoption decisions for college-bound students, and college policies and practices for advising students enrolling in mathematics courses.

Post, T. R., Monson, D. S., Anderson, E., & Harwell, M. R. (2012). Integrated curricula and preparation for college mathematics. *The Mathematics Teacher*, 106(2), 138–143.

This study examined the performance of students in one suburban school district that implemented NSF-funded mathematics curricula in grades K–12 for all students. Even though this district was high achieving before the change, it is now one of the top two or three highest-performing districts in the state regarding graduation rates, standardized test scores, the number and percentage of students in AP calculus and AP statistics courses, the percent- age of students who take four full years of college- intending mathematics (through *Core-Plus Mathematics* Course 4), and the percentage of students enrolled in four-year post- secondary institutions (Monson, 2011).

The results of this study have been validated by several additional multi-school studies in Minnesota. The NSF-funded curricula included in these studies prepare students for college mathematics equally as well as commercially developed, single-subject approaches. Evidence further suggests there may also be precollege pedagogical and sociological advantages to adopting NSF-funded curricula.

Teuscher, D., & Reys, R. E. (2012). Rate of change: AP calculus students' understandings and misconceptions after completing different curricular paths. *School Science and Mathematics*, 112(6), 359–376.

This study examined Advanced Placement calculus students' mathematical understanding of rate of change, after studying four years of college preparatory mathematics using *Core-Plus Mathematics* or conventional, single-subject texts. Students completed the Precalculus Concept Assessment (PCA) and two open-ended tasks with questions about rates of change. After adjusting for prior achievement with the Iowa Algebra Aptitude Test, students from these two paths performed comparably ( $F = 3.54$ ,  $p = .063$ ) on the PCA. Student errors on the three instruments revealed a lack of understanding of the interpretation or meaning of rate of change regardless of the curricular path.

Chávez, Ó., Papick, I., Ross, D. J., & Grouws, D. A. (2011). Developing fair tests for mathematics curriculum comparison studies: The role of content analyses. *Mathematics Education Research Journal*, 23(4), 397–416.

This paper describes the process of development of assessment instruments for a three-year longitudinal comparative study that focused on evaluating U.S. high school students' mathematics learning from two distinct approaches to content organization: curricula built around a sequence of three full-year subject-specific courses (Algebra 1, Geometry, and Algebra 2) and the *Core-Plus Mathematics* sequence of integrated mathematics courses (algebra and geometry content, together with functions, data analysis, probability, and discrete mathematics integrated in each year). The study was conducted in six school districts in five states involving over 4,000 students from schools that were using both curricular approaches but with different groups of students. In order to develop assessment instruments that were not biased toward either of the two curriculum approaches (Fair Tests), an iterative process of content analyses, identification of common topics, internal and external reviews, pilot tests, and revisions was followed, resulting in five tests that were used in the three years of the study. Results indicate that these tests have solid discrimination properties and address adequately mathematics content common to both secondary curriculum programs. The corresponding scoring rubrics are highly reliable, with interrater reliability above 94% for all tests. Mathematics education researchers involved in curriculum comparison studies need to conduct content analyses of the curriculum materials under study in order to identify salient relationships between curriculum programs and student outcomes.

Norman, K. W., Medhanie, A. G., Harwell, M. R., Anderson, E., & Post, T. R. (2011). High school mathematics curricula, university mathematics placement recommendations, and student university mathematics performance. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies*, 21(5), 434–455.

Recent “math wars” have drawn attention to how well various high school mathematics curricula prepare students for college-level mathematics. The purpose of this study was to investigate the relationship between the type of high school mathematics curricula (integrated or conventional single-subject) and students' post-secondary mathematics placement recommendation, specifically how students responded to the mathematics placement recommendations and the students' performance in their first college mathematics class. The results showed no relationship between students' participation in a particular high school mathematics curriculum and mathematics placement recommendation, or between student high school mathematics curriculum and students' responses to a university mathematics placement recommendation. However, students who took a more/less difficult class than what was recommended achieved significantly lower/higher grades than those who followed the recommendation. The findings have implications for high school mathematics curricula selection, post-secondary student placement, and future research in this area.

Capraro, M. M., Capraro, R. M., Yetkiner, Z. E., Rangel-Chavez, A. F., & Lewis, C. W. (2010). Examining Hispanic student mathematics performance on high-stakes tests: An examination of one urban school district in Colorado. *Urban Review: Issues and Ideas in Public Education*, 42(3), 193–209.

Mathematics achievement scores from the Colorado Student Assessment Program and Measurement of Academic Progress for Hispanic 9th and 10th grade students ( $n = 1,318$ ) who used the *Core-Plus Mathematics* program were compared to the performance of students with other demographic backgrounds ( $n = 2,003$ ) who used the same curriculum. The results of this study indicated that Hispanic students showed modest gains. However, their relative position compared to other ethnic groups remained low.

Post, T. R., Medhanie, A., Harwell, M., Norman, K. W., Dupuise, D. N., Muchlinski, T., Anderson, E., & Monson, D. (2010). The impact of prior mathematics achievement on the relationship between high school mathematics curricula and post-secondary mathematics performance, course-taking, and persistence, *Journal for Research in Mathematics Education*, 41(3), 274–308.

This retrospective study examined the impact of prior mathematics achievement on the relationship between high school mathematics curricula and student post-secondary mathematics performance. The sample ( $N = 4,144$  from 266 high schools) was partitioned into three strata by ACT mathematics scores. Students completing three or more years of a commercially developed, University of Chicago School Mathematics Project curriculum, or National Science Foundation-funded curricula comprised the sample. Of interest were comparisons of the difficult level and grade in their initial and subsequent college mathematics courses, and the number of mathematics courses completed over eight semesters of college work. In general, high school curriculum was not differentially related to the pattern of mathematics grades that students earned over time or to the difficulty levels of the students' mathematics course-taking patterns. There also was no relationship between high school curricula and the number of college mathematics courses completed.

Harwell, M., Post, T. R., Maeda, Y., Davis, J., Cutler, A., Anderson, E., & Kahan, J. A. (2007). *Standards-based mathematics curricula and secondary students' performance on standardized achievement tests*. *Journal for Research in Mathematics Education*, 38(1), 71–101.

The current study examined the mathematical achievement of high school students enrolled for three years in one of the three 1st-edition NSF-funded *Standards-based curricula (Core-Plus Mathematics, Interactive Mathematics Program, Mathematics Modeling Our World)*. The focus was on traditional topics in mathematics as measured by subtests of a standardized achievement test and a criterion-referenced test of mathematics achievement. Students generally scored at or above the national mean on the achievement subtests. Hierarchical linear modeling results showed that prior mathematics knowledge was a significant but modest predictor of achievement, student SES had a moderate effect, and increasing concentrations of African-American students in a classroom were associated with a stronger effect of attendance on achievement. No differences on the standardized achievement subtests emerged among the *Standards-*

based curricula studied once background variables were taken into account. The two suburban districts providing data for the criterion-referenced test achieved well above the national norm.

Herbel-Eisenmann, B., Lubienski, S., & Id-Deen, L. (2006). Reconsidering the study of mathematics instructional practices: The importance of curricular context in understanding local and global teacher change. *Journal of Mathematics Teacher Education*, 9, 313–345.

This paper discusses the case of one teacher, Jackie, whose instructional practices illuminate the importance of textbooks and student/parent expectations in shaping pedagogy. Jackie teaches in the Plainview district, which offers parents and students a choice between a reform-oriented, integrated curriculum (*Core-Plus Mathematics*) and a more conventional single-subject sequence (the University of Chicago series). Each day, Jackie teaches two very different sections of accelerated eighth-grade mathematics using each of these curricular materials. Drawing from students' survey responses, classroom observations, and teacher interview data, we show ways in which Jackie's pedagogy differs considerably between the two courses and we shed light on reasons underlying this variation. By examining one teacher who enacts different practices in each of the two curricular contexts, this paper highlights factors that contribute to teachers' enacted curricula factors that have been understated in previous mathematics education research on teacher development. The study establishes the importance of distinguishing between global and local teacher change and suggests implications for future studies of teaching and reform.

Lubienski, S. T. (2004). Traditional or *Standards*-based mathematics? The choices of students and parents in one district. *Journal of Curriculum and Supervision*, 19(4), 338–365.

This study examines students' and parents' choices in one district that recently began offering a new problem-centered high school mathematics program aligned with the National Council of Teachers of Mathematics *Standards*, in addition to its traditional mathematics sequence. Despite the district's previous implementation of *Standards*-based instruction in grades K through 8, the vast majority of students and parents have chosen the traditional high school sequence. Survey data from more than 300 students and parents were analyzed with attention to parent education level and option chosen. Parents with limited formal education were less likely than college-educated parents to access information about the options but were more likely to rank college preparation as a top factor in their decision. Additionally, although college-educated parents were more likely than other parents to discuss the options with teachers, they were less likely to be influenced by teachers' comments. Parents who chose the traditional sequence expressed more concern about college preparation, whereas parents who chose the *Standards*-based sequence placed a higher priority on student understanding and enjoyment of mathematics. Overall, many parents and students in the district held strong, persistent anti-reform beliefs. This study highlights the difficulties and dilemmas of introducing change into the firmly entrenched mathematics curriculum, particularly at the high school level.

Latterell, C. M. (2003). Testing the problem-solving skills of students in an NCTM-oriented curriculum. *The Mathematics Educator*, 13(1), 5–14.

An interesting question concerns how well students from a *Standards*-based curriculum do on standardized mathematics tests. (This has been addressed by many of the evaluation and research studies summarized in this bibliography.) Another important question that has received less attention is: Are standardized tests truly measuring the skills and understanding that *Standards*-based students have? Would other tests reveal skills and understandings that differentiate students from *Standards*-based curricula from those who studied a more traditional program? Moreover, what are these skills? This paper contributes tentative answers to some of these questions, in the case of *Core-Plus Mathematics*. The reported study found that students who studied from the *Core-Plus Mathematics* program displayed qualities such as engagement, eagerness, communication, flexibility, and curiosity to a much higher degree than did students who studied from more conventional subject-specific programs.

Schoen, H. L., & Hirsch, C. R. (2003, February). Responding to calls for change in high school mathematics: Implications for collegiate mathematics. *American Mathematical Monthly*, pp. 109–123.

This paper briefly discusses the recent history of mathematics reform in high school, and then reports on research evidence for one of the new NSF-funded curriculum projects, the Core-Plus Mathematics Project (CPMP). Implications for collegiate mathematics are also discussed. A summary of the results of several studies using a range of achievement measures comparing CPMP students to comparable students in more traditional high school mathematics curricula is given on page 114:

Thus, research to date indicates that CPMP students perform particularly well [and better than the comparison students] on measures of conceptual understanding, interpretation of mathematical representations and calculations, and problem solving in applied contexts. Their performance is also relatively strong in content areas like statistics and probability that are emphasized in the curriculum. On measures of algebraic manipulative skills, CPMP students usually, but not always, score as well as students in more traditional curricula.

A study of student performance on a mathematics placement test used at a major Midwest university is summarized on page 116:

On the algebra subtest, the means of the [traditional] precalculus students and the CPMP Course 4 students were virtually identical. On the intermediate algebra subtest, the mean of the precalculus group was greater than that of the Course 4 group. The only statistically significant difference in means was on the calculus readiness subtest ( $t = 4.93$ ,  $p < 0.01$ ). That difference favored the CPMP students.

Group calculus readiness test items means differed significantly on 12 of the twenty calculus readiness items, 11 in favor of the CPMP students and one in favor of the other direction.

Schoen, H. L., Finn, K. F., Cebulla, K. J., & Fi, C. (2003). Teacher variables that relate to student achievement when using a standards-based curriculum. *Journal for Research in Mathematics Education*, 34(3), 228–259.

This paper reports results from a study of instructional practices that relate to student achievement in high school classrooms in which a standards-based curriculum (*Core-Plus Mathematics*) was used. Regression techniques were used to identify teachers' background characteristics, behaviors, and concerns that are associated with growth in student achievement and further described these associations via graphical representations and logical analysis. The sample consisted of 40 teachers and their 1,466 students in 26 schools. Findings support the importance of professional development specifically aimed at preparing to teach the curriculum. Generally, teaching behaviors that are consistent with the standards' recommendations and that reflect high mathematical expectations were positively related to growth in student achievement.

Martin, T. S., Hunt, C. A., Lannin, J., Leonard, W., Jr., Marshall, G. L., & Wares, A. (2001). How reform secondary mathematics textbooks stack up against NCTM's *Principles and Standards*. *Mathematics Teacher*, 94(7), 540–545, 589.

The authors examined five reform high school mathematics textbook series, including the Core-Plus Mathematics Project texts, *Contemporary Mathematics in Context* (CMIC), to determine how well they are aligned with the NCTM's *Principles and Standards for School Mathematics* (PSSM). CMIC was rated highest among the four programs in each of the process standards, that is, problem solving, reasoning and proof, communication, connections, and representations. CMIC was also rated a "+" for inclusion of all content topics from PSSM.

Huntley, M. A., Rasmussen, C. L., Villarubi, R. S., Sangtong, J., & Fey, J. T. (2000). Effects of *Standards*-based mathematics education: A study of the Core-Plus Mathematics Project algebra and functions strand. *Journal for Research in Mathematics Education*, 31(3), 328–361.

Students in CPMP 1st edition Course 3 and those in more traditional Algebra II classes, matched on measures of eighth-grade mathematics achievement, were administered a researcher-developed test of algebraic understanding, problem solving, and procedural skill at the end of the school year. CPMP students scored significantly better on the subtests of understanding and problem solving, and Algebra II students scored significantly better on the subtest of paper-and-pencil procedures. Scores and student work are discussed by item in this paper.

Schoen, H. L., Fey, J. T., Hirsch, C. R., & Coxford, A. F. (1999). Issues and options in the math wars. *Phi Delta Kappan*, 80(6), 444–453.

This article revisits the historical background for the development of the 1989 NCTM *Curriculum and Evaluation Standards*, including the attempts at gaining a consensus among professional organizations with interest in mathematics and its related fields. Specific features of a 9–12 curriculum developed by the Core-Plus Mathematics Project that is aligned with the NCTM *Standards* are described. Finally, some results from the



evaluation of the CPMP curriculum that have a bearing on some of the main issues raised by critics of the NCTM reform effort are presented and discussed.

Hirsch, C. R., & Coxford, A. F. (1997). Mathematics for all: Perspectives and promising practices. *School Science and Mathematics*, 97(5), 232–241.

This article describes CPMP perspectives on a new curriculum organization for high school mathematics, identifies implications of these perspectives for promoting access and equity for all students, and reports some of the supporting oral data from the ongoing formative evaluation of the curriculum. The focus is on diversity issues related to ability, prior knowledge, gender, interests, and learning styles.

## Peer-Reviewed Book Chapters and Books

Tarr, J. E., McNaught, M. D., & Grouws, D. A. (2012). The development of multiple measures of curriculum implementation in secondary mathematics classrooms: Insights from a three-year curriculum evaluation study. In D. Heck, K. Chval, I. Weiss, & S. W. Ziebarth (Eds.), *Approaches to studying the enacted mathematics curriculum* (pp. 89–116). Greenwich, CT: Information Age.

The authors examine curriculum implementation and methods used by the Comparing Options in Secondary Mathematics: Investigating Curriculum (COSMIC) project to gather information related to student mathematical learning associated with secondary mathematics curriculum programs such as *Core-Plus Mathematics*. The authors discuss their conceptual approach to instrument development, outline their instrument development process, describe the instruments developed, and provide reliability and validity data.

Schoen, H. L., Ziebarth, S. W., Hirsch, C. R., & BrckaLorenz, A. (2010). *A five-year study of the first edition of the Core-Plus Mathematics curriculum*. Charlotte, NC: Information Age.

The study reported in this volume adds to the growing body of evaluation studies that focus on the use of NSF-funded *Standards*-based high school mathematics curricula. Most previous evaluations have studied the impact of field-test versions of a curriculum. Since these innovative curricula were so new at the time of many of these studies, students and teachers were relative novices in their use. These earlier studies were mainly one year or less in duration. Students in the comparison groups were typically from schools in which some classes used a *Standards*-based curriculum and other classes used a conventional curriculum, rather than using the *Standards*-based curriculum with all students as curriculum developers intended.

The volume reports one of the first studies of the efficacy of *Standards*-based mathematics curricula with all of the following characteristics:

- The study focused on fairly stable implementations of a 1st-edition *Standards*-based high school mathematics curriculum that was used by all students in each of three schools.

- It involved students who experienced up to seven years of *Standards*-based mathematics curricula and instruction in middle school and high school.
- It monitored students' mathematical achievement, beliefs, and attitudes for four years of high school and one year after graduation.
- Prior to the study, many of the teachers had one or more years of experience teaching the *Standards*-based curriculum and/or professional development focusing on how to implement the curriculum well.
- In the study, variations in levels of implementation of the curriculum are described and related to student outcomes and teacher behavior variables.

Item data and all unpublished testing instruments from this study are available at [www.wmich.edu/cpmp/](http://www.wmich.edu/cpmp/) for use as a baseline of instruments and data for future curriculum evaluators or *Core-Plus Mathematics* users who may wish to compare results of new groups of students to those in the present study on common tests or surveys. Taken together, this volume, the supplement at the CPMP Web site, and the 1st-edition *Core-Plus Mathematics* curriculum materials (samples of which are also available at the Web site) serve as a fairly complete description of the nature and impact of an exemplar of 1st-edition NSF-funded *Standards*-based high school mathematics curricula as it existed and was implemented with all students in three schools around the turn of the 21st century.

Ziebarth, S. W., Hart, E., Marcus, R., Ritsema B., Schoen, H. L., & Walker, R. (2008). High school teachers as negotiators between curriculum intentions and enactment. In J. Remillard, G. Lloyd, & B. Herbel-Eisenmann (Eds.), *Mathematics teachers at work* (pp. 171–189). New York: Routledge Falmer.

This chapter reports on an investigation of secondary mathematics teachers' interactions with authors of the *Core-Plus Mathematics* curriculum as the materials were being developed. Attention is focused on the ways in which the intended curriculum is negotiated by highlighting how teachers participate in the curriculum development process from early drafts to a final published commercial product. The authors describe some of the changes in content, teaching, and assessment that are common to the new reform high school programs, with examples from the Core-Plus Mathematics Project. They also consider implications for the role that middle school mathematics education plays in the development of common themes.

Fey, J. & Hirsch, C. (2007). The case of *Core-Plus Mathematics*. In C. Hirsch (Ed.), *Perspectives on the design and development of school mathematics curricula* (pp. 129–142). Reston, VA: National Council of Teachers of Mathematics.

This book presents a historical perspective on what is perhaps a unique effort in curriculum development in this country. The directors or associates for 15 comprehensive curriculum development projects, 14 of which were funded by the National Science Foundation, offer perspectives on the design principles that guided their work as well as insights into the challenges they faced and the barriers to their success. The book furnishes useful guidance to future curriculum developers and documents an important historical record of school mathematics.

Chapter 10 of this book discusses the design principles and development process for the *Core-Plus Mathematics* curriculum. A companion paper (entry below) describes the impact of the published curriculum on student learning and dispositions.

Schoen, H. L., & Hirsch, C. R. (2003). The Core-Plus Mathematics Project: Perspectives and student achievement. In S. Senk & D. Thompson (Eds.), *Standards-based school mathematics curricula: What are they? What do students learn?* (pp. 311–344). Hillsdale, NJ: Lawrence Erlbaum Associates.

This chapter provides an overview of the CPMP curriculum in terms of its design and theoretical framework and a profile of student outcomes. Achievement results are reported from the three-year *Core-Plus Mathematics* field test (1994–97) for each subtest of the standardized Ability to Do Quantitative Thinking (ATDQT) test and for students who scored in the top, middle, and bottom third on the ATDQT pretest. Results on measures of students' understanding of algebraic and geometric concepts and methods and of statistics, probability, and discrete mathematics are also presented. Students' perceptions and attitudes about mathematics and about their mathematics course are summarized. Finally, SAT and ACT scores of students in CPMP are compared to those in more traditional curricula. On all measures except paper-and-pencil algebra skills, students in CPMP do as well as or better than those in traditional curricula.

## Papers Presented at Research Conferences

Grouws, D. A., Tarr, J. E., Sears, R., & Ross, D. J. (2010). *Mathematics teachers' use of instructional time and relationships to textbook content organizations and class period format*. Paper presented at the Hawaii International Conference on Education, Honolulu, HI.

In this paper we report findings and implications related to secondary school mathematics teachers' use of instructional time and how patterns of classroom time utilization relate to the type of textbook used (content organization) and the class period format in place. The findings reported are based on data collected from 325 classroom observations of 109 teachers in 5 states during the first two years of the NSF-funded project, Comparing Options in Secondary Mathematics: Investigating Curriculum (COSMIC), a longitudinal comparative study of the impact of high school mathematics curricula on students' learning. Class time data were classified and analyzed based on Activity Codes (e.g., Warm-Up, Review, Lesson Preview, Teach, Practice and Apply, Assess) and two textbook types: subject-specific content organization (Algebra, Geometry, and Algebra II), in which the content each year is centered around a core mathematics area; and integrated content organization (Course 1, Course 2, Course 3), where the content is presented in an integrated manner with attention to algebra, geometry, statistics, and discrete mathematics each year. Three class period formats (regular, block, modified block) were taken into account. Teachers of the integrated curriculum spent significantly more time developing new mathematical ideas than did teachers of the subject-specific curriculum, but this came at the expense of students practicing and applying what they had learned during class time. This paper provides

summary descriptions of time utilization, identifies activity codes where there is substantial variation across curriculum types, and suggests factors that may account for variation in time utilization.

Smith, J., & Burdell, C. (2001). *The math is different, but I can deal: Studying students' experiences in a reform-based mathematics curriculum*. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

The research reported in this paper describes the mathematical experiences of 9 students who moved from a traditional mathematics program in junior high school to a high school mathematics program structured by current reforms in curriculum and teaching. We will refer to the high school site of this work as Logan High (though the name is fictitious). Logan has for some years implemented the Core-Plus Mathematics Project materials for most of its grades 9–12 students, including some (but not all) students who come out of the “advanced” mathematics track in the junior high school. We recruited 24 Logan student volunteers starting in January 2000 and have tracked these students in their mathematics work for 2.5 semesters.

We report on the experiences of 9 of these students, drawing on a maximum of three semesters of mathematics coursework (Spring 2000, Fall 2000, and Spring 2001). We have analyzed their mathematical experiences along four dimensions: (1) performance in mathematics, (2) disposition toward the subject, (3) approach to learning the subject, and (4) differences students see between traditional and *Core-Plus Mathematics* curricula and teaching. All of our 9 students reported differences between their past and present mathematics programs as they moved into the *Core-Plus Mathematics* program, but in only 2 cases was there any significant change in performance across the curricular shift.

Schoen, H. L., Hirsch, C. R., & Ziebarth, S. W. (1998). *An emerging profile of the mathematical achievement of students in the Core-Plus Mathematics Project*. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA. (ERIC: ED 421351)

Achievement results are reported for the three-year *Core-Plus Mathematics* field test (1994–97) on the Standardized Ability to Do Quantitative Thinking (ATDQT) test for all schools with school means as the statistical unit. ATDQT results are also reported by school setting (urban, rural, or suburban), by make-up of classes (heterogeneous, high ability, low ability, etc.), by gender, by English or non-English first language, and for three classrooms of students with exceptionally high mathematical aptitudes. Results are also given for the various subtests of the CPMP posttest, an open-ended assessment instrument, and a test comprised of released items from the 1992 National Assessment of Educational Progress.

## Technical Reports

Core-Plus Mathematics Project. (2002, May). *Developing mathematical literacy*.

In 1997, the Core-Plus Mathematics Project began a 5-year longitudinal study of students in three high schools in which the 1st edition of *Core-Plus Mathematics* was used with all students. Of special interest was the impact of the curriculum on students' mathematical literacy. This interim report begins by reviewing the literature that makes the case for the importance of mathematical (or quantitative) literacy for all adults in contemporary society and outlines the attributes of mathematical literacy.

Next, a short summary is provided of the performance of Course 1, Course 2, and Course 3 field-test students on different versions of the Ability to Do Quantitative Thinking subtest of the nationally normed Iowa Tests of Educational Development.

Finally, development of a test of released items from the TIMSS assessment of general mathematical knowledge and its scoring are described. The test results of end-of-Course 3 students in the three longitudinal study schools are reported and compared to the performance of end-of-high school students in the U.S., the Netherlands, and the total international cohort. *Core-Plus Mathematics* students outperformed both the U.S. and international samples. Their performance was closest to that of the Netherlands, the top scoring country on the TIMSS general mathematical knowledge assessment.

Core-Plus Mathematics Project. (2000). *Contemporary Mathematics in Context evaluation results*. Chicago, IL: Everyday Learning Corporation.

This booklet summarizes the methodology and main results of the national field tests of 1st edition Courses 1–4 of the Core-Plus Mathematics Project curriculum. Included are results of studies reporting the performance of CPMP students and comparable students in more traditional curricula on the ITED Ability to Do Quantitative Thinking subtest, a NAEP-based test, the SAT, the ACT, and a university mathematics department placement test, and in beginning college mathematics courses. Also reported are findings from a study of attitudes and beliefs of CPMP students and comparable students in more traditional curricula at the end of their second year of high school mathematics.

Core-Plus Mathematics Project. (1998). *Contemporary Mathematics in Context student achievement reports, volume I*. Chicago, IL: Everyday Learning Corporation.

This booklet consists of eight reports. The first report summarizes results from the national field test of 1st-edition Courses 1–3 of the Core-Plus Mathematics Project curriculum. The remaining reports contain firsthand accounts by teachers of how the curriculum was implemented in their schools. These reports focus on the positive experiences that teachers and students enjoyed as a result of their use of the *Contemporary Mathematics in Context* curriculum materials. They also comment on issues of implementation, community involvement, tracking, test results, student and teacher attitudes, and enrollment patterns.

Schoen, H. L., & Ziebarth, S. W. (1998). *Assessment of students' mathematical performance: A Core-Plus Mathematics Project field-test progress report*. Unpublished manuscript, University of Iowa.

This report focuses on standardized achievement test results aggregated across 33 field-test schools who were on a regular two-semester schedule. On the Ability to Do Quantitative Thinking, the mathematical subtest of the Iowa Tests of Educational Development, CPMP students in both Course 1 and Course 2 performed better across the distribution than comparison students in more traditional mathematics classes. CPMP students also grew more from the beginning of grade 9 to the end of each of grades 9, 10, and 11 than the nationally representative norm group for this test. At the end of Course 3, CPMP students performed particularly well on NAEP-developed measures of data analysis, probability and statistics, and on measures of conceptual understanding. Their performance was somewhat lower in some other content areas and on items assessing procedural outcomes, but still considerably higher than a nationally representative sample of 12th-grade students.

## Dissertations

Fonkert, K. L. (2012). *Patterns of interaction and mathematical thinking of high school students in classroom environments that include use of JAVA-based, curriculum-embedded software*. Unpublished doctoral dissertation, Western Michigan University.

This study analyzes the nature of student interaction and discourse in an environment that includes the use of Java-based, curriculum-embedded mathematical software. The software, *CPMP-Tools*, was designed as part of the development of the 2nd edition of the *Core-Plus Mathematics* curriculum. The use of the software on laptop computers used by students working in small groups or as a whole class in interactive lessons with a single computer at the front of the classroom was explored. Data were collected through observations, interviews, and selected items from the students' regular assessments. During the observations, classroom discussion was audiotaped and videotaped, and field notes were taken. The interviews of students and teachers were audio- and/or videotaped. The analysis of these data revealed that the students engaged in inquiry the majority of the time while they were using *CPMP-Tools* in small groups. Building on other students' ideas was the second most frequent interaction pattern in that setting. During the whole-class interactive lessons with a single computer, the two most frequently found interaction patterns were teacher explaining and giving new ideas. The most frequently occurring level of mathematical thinking found in both types of classroom environments using *CPMP-Tools* was the second-highest level in the framework—constructing and synthesizing. The students were habitually engaged in productive interaction patterns and high levels of mathematical thinking while using the curriculum-embedded software. The dynamic nature and strategic use of colorful visuals used in *CPMP-Tools* facilitated students' interactions and high levels of mathematical thinking.

Krupa, E. E. (2011). *Evaluating the impact of professional development and curricular implementation on student mathematics achievement: A mixed methods study*. Unpublished doctoral dissertation, North Carolina State University, Raleigh.

This study was designed to investigate the effects of an integrated, reform-based curriculum, *Core-Plus Mathematics*, on student learning on statewide End-of-Course exams (EOC—Algebra I and II) and to contextualize these outcomes in a state-funded professional development program with the elements of a summer program, follow-up workshops, and monthly site-based support with instructional coaches. The study was also designed to compare and contrast major subgroups: teachers using *Core-Plus Mathematics* who did or did not participate in different elements of the professional development. In addition, the study was designed to gather evidence on the variations among these groups on key implementation indices, and to use hierarchical linear modeling to investigate the role of these factors in predicting student outcomes. Hierarchical linear modeling was used to account for the nesting of students within teachers within schools to investigate the impact of integrated mathematics and subject-specific curricular materials on student achievement across students in North Carolina. The sample was then restricted to students of teachers who participated in the state-funded professional development to relate teacher characteristics to student outcomes. The sample was further restricted to teachers who participated in different components of the professional development to analyze how curricular implementation affects student achievement and to examine factors that influenced decisions teachers made when implementing *Core-Plus Mathematics*.

Findings from this study indicate that North Carolina students enrolled in *Core-Plus Mathematics* outperformed subject-specific students on the Algebra I End-of-Course exam, which was highly aligned with content in *Core-Plus Mathematics* Course 1, and performed no differently on the Algebra II exam, which was not aligned as well with *Core-Plus Mathematics* Course 3. There were favorable findings on the use of *Core-Plus Mathematics* in high-minority, high-needs schools. Consistently prior achievement, student grade level and race, and classroom attendance were related to student achievement, as well as teacher content knowledge, most notably for teachers of *Core-Plus Mathematics*. This study documented large variance in teachers' implementation of *Core-Plus Mathematics* based upon the professional development they received and their experiences using the materials with students. Factors that related to their implementation of the curriculum and related instructional practices included their beliefs about how students best learn mathematics; their trust of the curriculum; and systemic factors including mandatory state assessments, access to materials and technology resources, scheduling, and student transition to reform mathematics. Teachers enrolled in the summer workshops more faithfully implemented content from the textbooks, but instructional coaches were an important component to facilitating change in teachers' instructional practices. Results from this study demonstrate that teachers using *Core-Plus Mathematics* benefit from professional development designed to strengthen their mathematical content knowledge and reform-based instructional practices. Findings suggest encouraging results for the use of *Core-Plus Mathematics* with typically underserved student populations and among teachers who were provided with sustainable support following an authentic workshop experience.

Harvel, K. R. T. (2010). *The relationship between Core-Plus Mathematics Project and student achievement*. Unpublished doctoral dissertation, Wayne State University.

This study focused on the effectiveness of the Core-Plus Mathematics Project (CPMP) curriculum in terms of academic achievement. Students' perceptions on their use of *Core-Plus Mathematics* were also a focus of the study. Finally, differences in procedural and conceptual knowledge between genders were examined. The control group used a traditional subject-specific textbook and the treatment group used the same textbook along with *Core-Plus Mathematics*. The results of the study found no significant difference between the two groups in procedural knowledge. However, the treatment group using the CPMP curriculum performed significantly better on the state assessment than the control group. The study also showed that although the students in the treatment group had negative perceptions about using *Core-Plus Mathematics*, they performed better than students in the control group. Results of the study showed that although the females did better procedurally and conceptually than males, the differences were not statistically significant. *Core-Plus Mathematics* provided students with a rigorous, conceptually rich instruction that was based on the High School Content Expectations that were derived from national standards.

Cebulla, K. J. (2002). *High school students' conceptions of correlation after instruction*. Unpublished doctoral dissertation, University of Iowa.

This study examines the understandings of high school students about correlation and explores how the use of context in mathematics curricula relates to these understandings. Students were in four groups depending upon their academic year (sophomore or juniors), school, and mathematics course enrolled in during the year of the study (Course 2 or Course 3 of the Core-Plus Mathematics Project [CPMP] curriculum or Algebra II). Overall, students were successful on tasks involving interpretation of scatterplots and estimating correlation coefficients. Students performed better on descriptive tasks than on numeric and analytic tasks. Students used both statistical and non-statistical arguments when drawing and evaluating conclusions and tended to focus on the direction of association rather than the strength of association. Between-group differences favoring CPMP students were found in some content categories.

Kahan, J. A. (1999). *Relationships among mathematical proof, high-school students, and a reform curriculum*. Unpublished doctoral dissertation, University of Maryland.

This study assessed proof competence and approaches to proof of 315 end-of-year juniors in three high school sites. In each site, roughly half of the students were enrolled in *Core-Plus Mathematics* Course 3 and the other half in traditional Advanced Algebra. In each site, proof was very difficult for most students, and no significant difference for demonstrated overall competence with proof or for perceiving the need for mathematical proof was found between the groups. Analysis of written answers and interview data suggested several student misconceptions regarding proof and provided some insight into how the teaching of proof could be improved.



Walker, R. K. (1999). *Students' conceptions of mathematics and the transition from a Standards-based reform curriculum to college mathematics*. Unpublished doctoral dissertation, Western Michigan University.

This research examined students' conceptions about learning, knowing, and doing mathematics after studying four years of the Core-Plus Mathematics Project (CPMP) curriculum and how those conceptions influenced their college mathematics experiences. Upon graduation from high school the students ( $n = 256$ ) believed that mathematical concepts, principles, and generalizations were slightly more important than facts, formulas, and algorithms; that learning mathematics was more about constructing understanding than memorizing; that doing mathematics was more about making sense out of situations than just solving problems; and that mathematics was useful. Case studies of six students from five different high schools, in terms of their experiences and thinking throughout the first semester of mathematics at two major Midwestern universities, are also reported. Among the findings were that none of the six students had difficulty making the transition from the CPMP *Standards*-based curriculum to college mathematics.