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A Case Study of Multicultural Education and Problem-Centered Mathematics Curricula

Augusto V. C. Legaspi, Ph.D.
Assistant Professor of Psychology
University of Alaska Fairbanks

Anthony Rickard, Ph. D.
Associate Professor of Mathematics Education
University of Alaska Fairbanks

Abstract

Multicultural education is an important issue in K-12 mathematics education. However, efforts to address multicultural education in K-12 mathematics, including through curriculum materials, are generally perceived as unsuccessful or having limited impact. This case study examines how a problem-centered middle school mathematics curriculum addresses multicultural education and then draws on studies that have investigated the effects of the curriculum on the mathematics achievement of diverse groups of students. The results of this study show that the curriculum incorporates three categories of multicultural elements throughout the curriculum to address multicultural education. Moreover, the work of other researchers shows that the effects of the curriculum on the mathematics achievement of all students, especially diverse groups of students, are positive and well documented. This case study motivates future research into whether the positive effects of the curriculum on the mathematics achievement of diverse students is due, in whole or in part, to the problem-centered structure of the curriculum (e.g., accommodates more diverse learning styles), the multicultural elements in the curriculum (e.g., makes mathematics more meaningful to diverse students), or both. Further research should also examine how other problem-centered mathematics curricula address multicultural education, including the effects of such curricula on the mathematics achievement of diverse groups of students, and to what extent such curricula help students develop positive attitudes and understandings about people from different cultural groups.

Introduction

Multicultural Education and Mathematics Education

> Mathematics has been widely touted as the subject-matter field that has made the greatest strides in the development of national standards…and, consequently, is seen as the leader of the education reform movement. School reformers are optimistic about the potential for school renewal and excellence. The multicultural perspective holds that without excellence and equity, this reform is doomed to failure. Mathematics cannot be left out of the excellence-and-equity school reform equation (Ladson-Billings, 1995, p. 141).

The aim of multicultural education is to create equal education opportunities for all students by changing the total school environment in such a way that it reflects diverse groups in society and in the schools and classrooms (Banks, 1995, 1996; Gollnick & Chinn, 1998). Similarly, Grant and Sleeter (1989) look at multicultural education as resting on both equal opportunity and cultural pluralism. They describe equal opportunity as a planned and deliberate attempt for each student to have equal opportunity to learn, succeed, and become what he or she would like, regardless of sex, race, social-class background, or disability. Grant and Sleeter (1989) argue further that cultural pluralism means that there is no one best way to be American.

Tate (1996) argues that addressing multicultural education in K-12 mathematics has typically occurred within three areas:

> (1) working with culturally diverse students to improve affective factors (e.g., self-esteem and attitude), (2) adding more diversity to the mathematics teaching workforce, and (3) introducing multicultural elements into mathematics textbooks (pp. 190-191).

Efforts at addressing multicultural education within these areas have commonly met with limited success and are generally regarded as inadequate (e.g., Sleeter, 1997; Tate, 1996). Seeking to improve how multicultural education is addressed in all K-12 subjects, including mathematics, teacher preparation programs have sought to address multicultural education, viewing it as a critical area within teacher education (Sleeter, 2001). Some teacher education programs utilize guidelines and resources that have been developed to provide detailed frameworks to teacher educators, school administrators, and preservice and inservice teachers about how to address multicultural education in schools, communities, and curriculum (e.g., see Alaska Native Knowledge Network, 1998).

Some researchers argue that a central multicultural education goal for K-12 mathematics should be "…providing students with a mathematics education that prepares them to make decisions on complex political issues that arise within our democratic society" (Tate, 1996, p. 198). However, other researchers have demonstrated that such

goals may not be consistently met in the classroom. For example, Theule-Lubienski (1997) showed that even with an informed teacher using curricula specifically designed to educate students in using statistical information for decision-making, students' success was mainly a function of their social and economic status. The picture that emerges from the research is that whether considering the preparation of mathematics teachers or teaching practice in mathematics classrooms, how K-12 mathematics addresses multicultural education is diffuse and only marginally effective (Gay, 1996; Mitchell & Salisbury, 2000; Sleeter, 2001). The need to meet the needs of diverse students and develop refined and effective multicultural education practices for K-12 schools, including mathematics, remains a serious and controversial challenge (Cochran-Smith, 2001).

While trying to improve minority students' attitudes and beliefs about mathematics, recruiting more culturally diverse mathematics teachers, and adding multicultural elements to mathematics texts are the predominant ways K-12 mathematics has attempted to address multicultural education (Tate, 1996), Banks (1994) argues that there are three major approaches that have been used to address multicultural education in all areas of the K-12 schooling: (1) Curriculum reform, which includes modifying the curriculum to incorporate content about different cultural groups and perspectives; (2) achievement, which stresses the need to develop theories and practices to increase the academic achievement of students from diverse backgrounds; and (3) intergroup education, which attempts to help all students develop positive attitudes and understandings about people from different cultural groups. Banks (1994, 1996) shows that there are many examples of how these three approaches are implemented: Incorporating multicultural content into textbooks and workshops, developing multicultural guides for various curricula, and observing diverse holidays (i.e., curriculum reform); special language, cultural, and mathematics and science programs for female and minority students (i.e., achievement); and desegregating schools and implementing cooperative learning in classrooms (i.e., intergroup education). Banks' (1994) general approaches to multicultural education are consistent with those identified earlier specifically for mathematics education by Tate (1996). For example, integrating multicultural elements (e.g., names and pictures of diverse students, information about aspects of different cultures connected to the content) into mathematics textbooks is consistent with curriculum reform, recruiting more diverse mathematics teachers is one way of implementing intergroup education, and achievement may be improved through improved attitudes and beliefs (c.f., Banks, 1994; Tate, 1996).

Problem-Centered Mathematics Curriculum and Multicultural Education

A central focus of reform efforts for K-12 mathematics for over 20 years has been that mathematics should be taught and learned as problem solving (c.f., NCTM, 1980, 1989, 1995, 2000). This has led to the development of problem-centered materials and curriculum for K-12 mathematics in which mathematics is taught and learned as problem solving. Problem-centered mathematics curricula provide students and teachers with mathematically rich situations that encourage exploration of mathematics where students are active in constructing their own mathematical knowledge. With problem-

centered curricula, students, guided by the teacher, learn not only about mathematics content but also about mathematical processes such as problem solving, reasoning and proof, communication, representation, and connections (NCTM, 1991, 2000).

Problem-centered mathematics curricula hold promise as vehicles for addressing multicultural education in mathematics education. For example, problem-centered curricula have been demonstrated to be more effective at increasing mathematics achievement among diverse students than other mathematics curricula (R. Reys, B. Reys, Lapan, Holliday, & Wasman, 2003), achievement being one of three general approaches to addressing multicultural education put forth by Banks (1994). Moreover, Sleeter (1997) notes that when it comes to increasing achievement in mathematics for all students, some researchers argue, "…the central issue is teaching for deep understanding rather than for the rote memorization of mathematical procedures" (p. 682). Problem-centered mathematics curricula, as opposed to traditional school mathematics texts which focus on developing computational accuracy with thinly understood algorithms, are specifically designed to support teachers and students in developing conceptual and procedural understanding of mathematics, making connections between mathematical ideas, and connecting mathematics to students' lives (Rickard, 1993, 1998). For example, rather than teaching measurement concepts of perimeter and area as memorizing formulas like P = 2 x (L + W) and A = L x W to get answers to rote problems (e.g., "Find the perimeter and area of a rectangle with length six and width four"), a problem-centered curriculum helps students develop conceptual understanding of perimeter and area (e.g., perimeter as the number of units needed to surround a figure, area as the number of square units needed to cover a figure), build strategies through exploring problems to measure the perimeter and area of figures (e.g., use transparent grids to estimate the perimeter and area of rectangles, triangles, and irregular figures like handprints and blobs), and procedural understanding of perimeter and area by using relationships and connections between different figures to develop, apply, and build proficiency with perimeter and area formulas (e.g., deriving the area formula for triangles from the area formula for parallelograms and rectangles; see Lappan, Fey, Fitzgerald, Friel, & Phillips, 2004; Rickard, 1998). Reforming mathematics education to make mathematics accessible to all students, rather than the inaccessible purview of an elite group, is an intersecting goal of mathematics education reforms (e.g., problem-centered curricula) and multicultural education (c.f., NCTM, 2000; Tate, 1996).

Developing a Case Study

One way of investigating how and to what extent problem-centered curricula may address multicultural education is to analyze a specific problem-centered mathematics curriculum. In this case study, we unpack how a problem-centered mathematics curriculum addresses multicultural education through curriculum reform and achievement, two of the three key approaches to multicultural education identified by Banks (1994). By developing a case study of a problem-centered curriculum from the

multicultural education perspective of curriculum reform and achievement, the dynamics of how problem-centered mathematics curricula may impact diverse groups of students can be better understood.

The Connected Mathematics Project Curriculum

The problem-centered mathematics curriculum we analyze is the Connected Mathematics Project (CMP) curriculum (Lappan, Fey, Fitzgerald, Friel, & Phillips, 1996), which is a complete middle school mathematics curriculum for grades six, seven, and eight. The CMP curriculum is comprised of 24 individual units, eight at each grade level, with student and teacher editions for each unit. The teacher editions of each unit and supplementary materials (e.g., Lappan et al., 2002, 2004) provide extensive support to teachers in orchestrating the mathematical investigations within each unit. CMP is aligned with the NCTM Standards and takes a problem-centered, investigative approach to teaching and learning mathematics. For example, in the sixth-grade CMP unit *Prime Time* (see Lappan et al., 1996) students begin their study of factor pairs by finding all the ways to arrange 12 square tiles into rectangles, recording the length width of each rectangle, and then looking at their data for patterns. Under the guidance of the teacher, students find that 12 square tiles can be arranged into rectangles with length x width of 1 x 12, 2 x 6, 3 x 4, 4 x 3, 6 x 2, and 12 x 1 and that the area of each rectangle is 12. In mathematical terms, the students have developed geometric representations of the factor pairs of 12. Over the course of *Prime Time*, students go on to connect factor pairs to common multiples, prime factorizations, and establish that every whole number can be factored uniquely as a product of prime numbers (i.e., the Fundamental Theorem of Arithmetic). The *Prime Time* unit addresses the NCTM content standard of number and all of the NCTM process standards of problem solving, connections, communication, representation, and reasoning and proof (Lappan et al., 1996, 2002, 2004).

CMP has been in use for almost 10 years and extensive research has been conducted on implementation, student achievement, and teacher professional development with CMP (see Rivette, Grant, Ludema, & Rickard, 2003). In 1999, CMP was ranked highest of all nationally available middle school mathematics curricula by the American Association for the Advancement of Science. Also in 1999, CMP was one of five elementary, middle school, and high school mathematics curricula designated as "exemplary" by the U.S. Department of Education's Mathematics and Science Expert Panel. These recognitions suggest that CMP is a well-designed curriculum that clearly reflects the goals of mathematics education reform.

Methodology and a Framework for Analyzing CMP

To analyze how the CMP curriculum addresses multicultural education from the curriculum reform perspective, three categories were developed. Each category includes specific approaches for explicitly addressing multicultural education:

- Pictures, illustrations, or mention of people, places, or things that reflect diversity. For example, the seventh-grade CMP unit *Variables and Patterns* includes a

picture of Marie-Jose Perec, who won the gold medal for the women's 400-meter dash for France at the 1992 Olympic games (p. 32). The illustration is used to enhance a problem about how winning times in the women's 400-meter dash have changed over time.

- Text that provides specific information about people, places, things, or issues that reflect diversity. Any text that provides information about people, places, things, or issues that reflect diversity for students is included in this category. For example, the sixth-grade CMP unit *Data About Us* includes a "Did you know?" information box which discusses how in parts of Africa names of children are very meaningful and reflect the family's religious beliefs or important events which occurred at the time of the child's birth; examples of African names and their meanings are also provided (p. 9).
- A problem or project that involves learning about a multicultural topic, issue, or population within the context of learning and exploring mathematics. Text that provides students with a multicultural topic, issue, or population and engages them in a problem or activity (e.g., developing different strategies for measurement) is included in this category. For example, in the seventh-grade CMP unit *Comparing and Scaling* Problem 6.3 provides students with 1990 census data about the population and demographics of the United States. The census data includes information about the number of people in each state who live in metro and rural areas, as well as the number of people in each state reporting their identity as White, Black, Hispanic, Native American, Eskimo, or Aleut, and Asian or Pacific Islander. Problem 6.3 requires students to use the census data to develop guidelines for membership in a 1000-member council that would represent all of these racial and ethnic groups in the same proportion as they are represented in the entire U.S. population (pp. 70-72).

The above three categories represent increasingly substantive approaches to explicitly addressing multicultural education in the CMP curriculum. The three categories incorporate what Tate (1996) calls "multicultural elements" and are intended to connect mathematics content and processes with multicultural content and understandings. This is especially the intent of the multicultural elements in the third category, which focuses on developing connections between mathematics and cultures as students learn about both simultaneously. By quantifying (i.e., counting) each instance in each unit of the CMP curriculum where these categories are addressed, a measure of how and to what extent CMP explicitly (i.e., within the text of the CMP student materials) addresses multicultural education can be determined.

The three-part framework was developed after careful review of the CMP curriculum to get a sense of how CMP explicitly addresses multicultural education. The three categories were also developed to be consistent with multicultural elements which Tate (1996) and other researchers cite as being ways in which curriculum materials in general, and mathematics curricula in particular, seek to address multicultural education (e.g., Banks, 1996; Nieto, 2000; Sleeter, 1997, 2001). For example, the first category of the framework, "pictures, illustrations, or mention of people, places, or things that reflect diversity," is a multicultural element Banks (1996) identifies as "content integration"

frequently used in curriculum to address multicultural education. Pictures and illustrations are included as a category of the framework because they do represent one way of addressing multicultural education even though some researchers criticize their use (e.g., Sleeter, 1997, notes that names, pictures, or illustrations used to portray diversity in mathematics curriculum are typically used superficially). The other two categories of the framework reflect multicultural elements that are more substantive than pictures and illustrations. For example, Sleeter (1997) suggests that elements within a mathematics curriculum that help students understand social issues and connect mathematics to the world around them are substantive multicultural elements that may also help increase students mathematics achievement. The categories of the framework, "text that provides specific information about people, places, things, or issues that reflect diversity" and "a problem or project that involves learning about a multicultural topic, issue, or populations within the context of learning mathematics" reflect multicultural elements within the CMP curriculum that potentially meet the criteria Sleeter (1997) identifies as providing a more robust way of addressing multicultural education in a mathematics curriculum.

It is important to note that the framework does not include names of people as a way of addressing multicultural education. First, this is because throughout all of the CMP units a variety of names reflecting diversity are consistently used. For example, in the CMP unit *Prime Time* (Lappan et al., 1996), names of people used in the text of the unit include Emilio, Keiko, Lupe, Ji Young, Min Ji, Sharlina, Lon, Rosa, and Ivan. This sample of names from *Prime Time* refers only to students, but a like diversity of names appears consistently in CMP units referring to teachers and community members as well. Second, while the CMP curriculum consistently incorporates diverse names, such names are a typical feature of K-12 mathematics curricula and have also been criticized as a nonsubstantive way to address multicultural education (e.g., Sleeter, 1997). With these two issues in mind, we do not include names of people in the framework but do note that diverse names are used consistently throughout the CMP curriculum.

Analysis of How CMP Addresses Multicultural Education

To measure how and to what extent the CMP curriculum explicitly addresses multicultural education, each of the 24 student editions of the CMP units were analyzed for the number of items that fit into the three categories of the framework. Both authors and a student research assistant each conducted an independent analysis of the 24 CMP units with respect to the framework. The three sets of data were then compared, discrepancies were discussed, and final categorization of items that were not classified identically by all three was resolved by consensus. This process resulted in a final data set of how the CMP curriculum addresses multicultural education, using the three-part framework as an analytic lens. The data are summarized for each unit at each grade level in the following tables:

Table 1: CMP Grade 6

CMP Unit Title	Number of Pictures and/or Illustrations	Number of Informational Text(s)	Number or Problem(s) and/or Project(s)	Total Number of Multicultural Elements for Unit
Prime Time	2	0	0	**2**
Data About Us	3	4	1	**8**
Shapes and Designs	4	3	2	**9**
Bits and Pieces I	1	4	2	**7**
Covering and Surrounding	1	3	1	**5**
How Likely Is It?	2	1	1	**4**
Bits and Pieces II	2	0	3	**5**
Ruins of Montarek	11	6	7	**24**
Total for Grade 6	**26**	**21**	**17**	**64**

Table 2: CMP Grade 7

CMP Unit Title	Number of Picture(s) and/or Illustration(s)	Number of Informational Text(s)	Number of Problem(s) and/or Project(s)	Total Number of Multicultural Elements for Unit
Variables and Patterns	3	1	2	**6**
Stretching and Shrinking	6	0	2	**8**
Comparing and Scaling	3	3	3	**9**
Accentuate the Negative	2	1	1	**4**
Moving Straight Ahead	5	2	5	**12**
Filling and Wrapping	3	2	2	**7**
What Do You Expect?	4	0	0	**4**
Data Around Us	5	11	16	**32**
Total for Grade 7	**31**	**20**	**31**	**82**

Table 3: CMP Grade 8

CMP Unit Title	Number of Picture(s) and/or Illustration(s)	Number of Informational Text(s)	Number of Problem(s) and/or Project(s)	Total Number of Multicultural Elements for Unit
Thinking with Mathematical Models	6	4	4	**14**
Looking for Pythagoras	2	7	3	**12**
Growing, Growing, Growing…	2	2	2	**6**
Frogs, Fleas, and Painted Cubes	4	3	0	**7**
Say It With Symbols	4	0	0	**4**
Kaleidoscopes, Hubcaps, and Mirrors	6	3	5	**14**
Samples and Populations	8	3	5	**16**
Clever Counting	0	1	2	**3**
Total for Grade 8	**32**	**23**	**21**	**76**

Another way of looking at how the CMP curriculum addresses the categories of the framework is to analyze the curriculum as a whole rather than as individual units. One way of accomplishing this is to assess which of the five NCTM content standards each unit addresses and then reorganize the data to show how the CMP curriculum holistically addresses the NCTM content standards for middle school mathematics. These data are summarized below in Table 4 and Table 5:

Table 4: CMP Units and the NCTM Content Standards*

NCTM Content Standard	Sixth-Grade CMP Unit(s)	Seventh-Grade CMP Unit(s)	Eighth-Grade CMP Unit(s)
Number and Operations	*Prime Time*, *Bits and Pieces I*, *Bits and Pieces II*.	*Comparing and Scaling*, *Accentuate the Negative*, *Data Around Us*.	*Clever Counting*.
Algebra	NONE	*Moving Straight Ahead*, *Variables and Patterns*.	*Thinking with Mathematical Models*, *Growing, Growing, Growing…*, *Frogs, Fleas, and Painted Cubes*, *Say It with Symbols*.
Geometry	*Shapes and Designs*, *Ruins of Montarek*.	*Stretching and Shrinking*.	*Looking for Pythagoras*, *Kaleidoscopes, Hubcaps, and Mirrors*.
Measurement	*Covering and Surrounding*.	*Filling and Wrapping*.	NONE
Data Analysis and Probability	*Data About Us*, *How Likely Is It?*	*What Do You Expect?*	*Samples and Populations*.

*Some CMP units address multiple NCTM Content Standards; this table classifies each unit according to the principal NCTM Content Standard that it addresses.

Table 5: Multicultural Elements in CMP by NCTM Content Standard**

NCTM Content Standard	Sixth-Grade CMP Multicultural Element(s) in each category	Seventh-Grade CMP Multicultural Element(s) in each category	Eighth-Grade CMP Multicultural Element(s) in each category	Total CMP Multicultural Element(s) in each category for NCTM Content Standard (all three grades combined)	Total Number of Multicultural Elements for NCTM Content Standard for all three grade levels
Number and Operations	(5, 4, 5)	(10, 15, 20)	(0, 1, 2)	**(15, 20, 27)**	**62**
Algebra	(0, 0, 0)	(8, 3, 7)	(16, 9, 6)	**(24, 12, 13)**	**49**
Geometry	(15, 9, 9)	(6, 0, 2)	(8, 10, 8)	**(29, 19, 19)**	**67**
Measurement	(1, 3, 1)	(3, 2, 2)	(0, 0, 0)	**(4, 5, 3)**	**12**
Data Analysis and Probability	(5, 5, 2)	(4, 0, 0)	(8, 3, 5)	**(17, 8, 7)**	**32**

**Multicultural elements are reported as ordered triples with the corresponding number of multicultural elements: (pictures/illustrations, informational text, problem/project).

What the data in Tables 1, 2, and 3 show is that individual units in the CMP curriculum vary widely in the extent to which they address multicultural education as measured by the categories of the framework. However, the curriculum as a whole, as viewed through the lens of the NCTM content standards, is more consistent in addressing multicultural

education (see Table 5). Together, these data show that CMP does address multicultural education throughout the curriculum whether looking at individual units, which vary significantly in the extent to which they address multicultural education, or looking at the curriculum holistically, which demonstrates a more consistent emphasis on multicultural education among the NCTM content standards of number, algebra, geometry, measurement and probability/statistics. Recall that the framework does not include data on diverse names used in the curriculum but that such names appear consistently throughout the CMP curriculum and in each individual unit.

The data used in the above analysis was gathered from the student editions of the 24 CMP units. It should be noted that while the CMP teacher editions provide detailed support and resources to CMP teachers (e.g., extensive solutions and suggestions for teaching mathematical investigations), no supplementary information for specifically addressing multicultural education (e.g., strategies to teach students about different cultures) was found (see Lappan et al., 1996). Additional resource materials available for CMP parallel the approach of the CMP teacher editions. For example, the *Connected Mathematics Lesson Planner for Grades 6, 7, and 8* (Lappan et al., 2002) is a resource guide for pacing instruction of individual units and provides strategies for organizing the entire CMP curriculum, as well as ideas for assessment and involving parents, but does not explicitly address multicultural education. However, one CMP resource guide (i.e., Lappan et al., 2004), which also focuses on implementation of the curriculum, does provide strategies for how to address the learning needs of students with learning disabilities and students who are in the process of learning English (e.g., English as a Second Language – ESL – students).

How CMP Impacts the Mathematics Achievement of Diverse Groups of Students

Rivette et al. (2003) summarized and synthesized research and evaluation studies that investigate implementation of the CMP curriculum, reporting that:

> The results consistently show that CMP students do as well as, or better than, non-CMP students on tests of basic skills. And CMP students outperform non-CMP students on tests of problem-solving ability, conceptual understanding, and proportional reasoning (p. 5).

The CMP curriculum is also associated with increases in mathematics achievement for minority students that, in general, matches or exceeds the increase in achievement for CMP students overall. For example, in 1996-99 the Ann Arbor, Michigan Public School District reported that increases in standardized math scores on the Michigan Educational Assessment Program (MEAP) test for CMP students significantly outpaced those of non-CMP student; the largest CMP student achievement gains were by African American students (Rivette et al., 2003). In Plano, Texas, the Plano Independent School District compared scores on the mathematics subtest of the Texas Assessment of Academic Skills (TAAS) of 2,336 students, 892 of whom used CMP in grades 6-8 during the 1998 and 1999 academic years:

> As a group, the CMP students' scores increased more than those of the non-CMP students. Moreover, economically disadvantaged, Hispanic, and African American students in the CMP group showed more growth than both the CMP group as a whole and the corresponding students in the non-CMP group. The CMP students classified as gifted and talented increased their already high scores slightly, making greater gains than the non-CMP gifted and talented students (Rivette et al., 2003, p. 22).

These and other findings suggest that CMP is an effective curriculum for all students and seems to have an especially positive impact on the mathematics achievement of minority students from diverse cultural groups (see Rivette et al., 2003, for summaries and citations of more studies on the effectiveness of CMP).

Conclusions and Implications

Key findings of this case study include that CMP does address multicultural education as demonstrated by the data presented in Tables 1, 2, and 3. Moreover, analysis of the data shows that there is significant variance among units within each of the three grade levels as to what extent multicultural education is addressed. For example, inspection of Table 1 for sixth grade shows that the CMP unit *Prime Time* incorporates a total of two multicultural elements while *Ruins of Montarek* includes a total of 24. Similar comparisons showing wide variation among the total multicultural elements of CMP units can be found in Table 2 for seventh grade. For example, *Accentuate the Negative* and *What Do You Expect?* each have a total of four multicultural elements whereas *Data Around Us* has 32. Table 3 for eighth grade demonstrates that *Say It With Symbols* has four multicultural elements compared to *Samples and Populations* with 16. From this data which focuses only on measuring the number of multicultural elements in CMP units and grades within three categories, it is not clear whether some CMP units are more or less effective than others at addressing multicultural education, but does show that, as measured by the framework, some units do have substantially more or fewer multicultural elements than others. However, some CMP units do stand out because they incorporate a high number of multicultural elements from the third category (which focus on learning mathematics within the context of learning about a multicultural topic, issue or population) relative to other CMP units. For example, the unit *Data Around Us* includes 16 multicultural elements from the third category and *Ruins of Montarek*, *Kaleidoscopes, Hubcaps, and Mirrors*, and *Samples and Populations* each include five or more.

A second conclusion from this curriculum case study is that CMP is more uniform in addressing multicultural education both between grade levels and among the five NCTM content standards than among individual units as noted above. For example, comparison of Tables 1, 2, and 3 shows that the total number of pictures and/or illustrations for grades six, seven, and eight is 26, 31, and 32, respectively. The same comparison for the

total number of informational texts for grades six, seven, and eight is 21, 20, and 23, respectively, and 17, 31, and 21, respectively, for the total number of problems and/or projects. While there is still significant variation between grade levels in the total number of multicultural elements within the three categories, it is markedly less than the variation among units within grades. Similarly, inspection of Table 5 shows that when the total number of multicultural elements in the CMP curriculum are grouped by the five NCTM content standards, (see fifth column of Table 5), the measurement strand has far fewer multicultural elements than the other strands. One reason for the outlier status of the measurement standards is that only two units in the CMP curriculum address measurement whereas each of the other four content standards is addressed by at least four units. Variation among the other four strands in the total number of multicultural elements is significant but not as substantial as between the individual CMP units within the same grade level.

A third conclusion can be drawn from the review of research that shows that CMP does have a significant and positive impact on the mathematics achievement of diverse students which seems to outpace not only non-CMP students' achievement gains but also the gains of all CMP students as well. One possible explanation for why CMP is successful with diverse students is that, as demonstrated by the data collected and analyzed in this case study, it addresses multicultural education and, therefore, allows more students to see mathematics as relevant to their lives and connected to their own experiences and to the global community. Another possible explanation is that a problem-centered curriculum like CMP is able to accommodate a broader range of learning needs and styles than traditional middle school mathematics curricula which typically focus on memorizing rules, facts, and rote algorithms (Rickard, 1995a, 1995b, 1996). It can be argued that the CMP curriculum supports the learning needs of diverse students because, as summarized in Rivette et al. (2003), the CMP authors have:

- Identified important mathematical ideas around which to focus each unit.
- Embedded the important ideas in interesting problems and contexts.
- Carefully sequenced the problems to help students develop deep understanding of concepts and skills.
- Devised problems that make connections among key mathematical ideas and to other disciplines.
- Structured the program to help students develop long-term proficiency in problem solving, reasoning, and use of skills.
- Included a variety of formal and informal assessment opportunities to help teachers assess student understanding in multiple ways.
- Provided teachers extensive assistance with the mathematics, pedagogy, and assessment in the curriculum (pp. 4-5).

Therefore, on the one hand, this case study shows that multicultural education is addressed by the CMP curriculum, suggesting that addressing multicultural education may be why CMP positively and significantly impacts the mathematics achievement of diverse students. On the other hand, CMP is a problem-centered curriculum that may allow more students, particularly diverse students, to develop deeper understanding and

more extensive skill in mathematics (see Reinhart, 2000 and Rickard 1995a, 1995b, 1996, 1998 for more information about how problem-centered curricula like CMP help students develop conceptual and procedural understanding of mathematics).

Taken together, these findings suggest that the CMP curriculum addresses curriculum reform and achievement, which are two of the three major approaches used to address multicultural education in K-12 schooling as identified by Banks (1994). CMP takes a curriculum reform approach because it incorporates multicultural elements aimed at helping students learn about different cultural groups and perspectives. By reviewing research on the effects CMP has on students' mathematics achievement, this curriculum case study also shows that CMP contributes to increasing the mathematics achievement of students from diverse backgrounds. A limitation of this research is that it provides no insight as to what extent CMP addresses intergroup education, Banks' (1994) third major approach to addressing multicultural education in curriculum, since we have no data about how using CMP affects students' attitudes and understandings about people from different cultural groups.

Directions for Future Research

Given the demonstrated effectiveness of CMP in increasing diverse students' mathematics achievement, to what extent does it matter whether CMP explicitly addresses multicultural education (as measured by the three-category framework) or not? Alternately, does CMP implicitly address multicultural education by providing a problem-centered mathematics curriculum that allows all students to learn mathematics in a way that allows personal ownership of the mathematics? Perhaps the problem-centered structure of CMP and that it does address multicultural education work in concert to support diverse students to increase their mathematical achievement (i.e., addressing the curriculum reform and achievement aspects of multicultural education simultaneously)? Finally, while some research has provided insight into how a teacher's use of problem-centered curricula like CMP affects the opportunities students have to develop conceptual and procedural understanding of mathematics and problem-solving skills (e.g., Rickard, 1998), how does a teacher's use of a curriculum that addresses multicultural education affect students' learning of mathematics?

Future research needs to investigate these and other questions to build a better understanding in the mathematics education community of how multicultural education, within the context of a problem-centered curriculum, can support students' learning of mathematics. For example, how do other problem-centered mathematics curriculum address multicultural education from the perspectives of curriculum reform, achievement, and intergroup education and how do they compare to CMP? While this case study provides some preliminary evidence that problem-centered mathematics curriculum can implement at least two approaches to multicultural education, future research should seek to disentangle the problem-centered and multicultural education aspects and how they impact students' (particularly diverse students') learning of mathematics. This case study

of the CMP curriculum suggests, for example, that a problem-centered mathematics curriculum can address both the curriculum reform and achievement approaches to addressing multicultural education, but provides no insight into how CMP addresses the third major approach, intergroup education. A refined understanding of the specific roles of problem-centered structure and multicultural education, and the interplay between the three approaches, could, for example, allow for better preparation and professional development for mathematics teachers leading to best practices for classroom teaching with problem-centered mathematics curricula that address multicultural education.

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