The Longitudinal/Cross-Sectional Study of the Impact of Teaching Mathematics using *Mathematics in Context* on Student Achievement

Monograph 2
2004

Background on Students and Teachers

Thomas A. Romberg

Lorene Folgert

University of Wisconsin-Madison

Mary C. Shafer

Northern Illinois University

WCER

Wisconsin Center for Education Research
School of Education - University of Wisconsin-Madison

The Longitudinal/Cross-Sectional Study of the Impact of Teaching Mathematics using *Mathematics in Context* on Student Achievement was carried out by the staff of the Wisconsin Center for Education Research, University of Wisconsin-Madison with the support of the National Science Foundation Grant No. REC 0553889. The analysis of the data gathered in this study was conducted by the staff of the Wisconsin Center for Education Research, University of Wisconsin-Madison and funded by the National Science Foundation Grant No. REC 0087511. Additional support for completing the monograph series was provided by Northern Illinois University.

Romberg, T. A., Shafer, M. C., & Folgert, L. (Editors). (2004). *Background on Students and Teachers* (Longitudinal/Cross-Sectional Study of the Impact of Teaching Mathematics using *Mathematics in Context* on Student Achievement: Monograph 2). Madison, WI: University of Wisconsin-Madison.

Romberg, T. A., & Shafer, M. C. (2004). Background information on students at the start of the study. In T. A. Romberg, M. C. Shafer, & L. Folgert (Editors), *Background on Students and Teachers* (Longitudinal/Cross-Sectional Study of the Impact of Teaching Mathematics using *Mathematics in Context* on Student Achievement: Monograph 2), 7–68. Madison, WI: University of Wisconsin-Madison.

Romberg, T. A., Shafer, M. C, Folgert, L., Balakul, S., Lee, C.,& Kwako, J. (2004). Information on teacher background variables. In T. A. Romberg, M. C. Shafer, & L. Folgert (Editors), *Background on Students and Teachers* (Longitudinal/Cross-Sectional Study of the Impact of Teaching Mathematics using *Mathematics in Context* on Student Achievement: Monograph 2), 69-85. Madison, WI: University of Wisconsin-Madison.

The L/CSS Monograph Series

This is the second of eight monographs derived from the NSF funded Longitudinal/Cross-Sectional Study of the impact of teaching mathematics using *Mathematics in Context* (National Center for Research in Mathematical Sciences Education & Freudenthal Institute, 1997-1998) on student achievement.

In 1992 the National Science Foundation funded several projects to develop new sets of instructional materials that reflected the reform vision of school mathematics espoused by the National Council of Teachers of Mathematics (NCTM, 1989). One of the funded projects was to the National Center for Research in Mathematical Sciences Education (NCRMSE) at the University of Wisconsin-Madison. The project was organized to develop a comprehensive mathematics curriculum for the grades 5-8 (NSF Grant No. ESI-9054928). Assisted by the staff of the Freudenthal Institute (FI) at the University of Utrecht in The Netherlands the *Mathematics in Context* (MiC) curriculum materials were created and field-tested prior to being published in 1997-1998 by Encyclopaedia Britannica.

In 1996 as the development of the MiC materials was nearing completion a proposal was submitted to the National Science Foundation to investigate how teachers were changing their instructional practices in schools whose staffs were using *Mathematics in Context*, and how such changed practices affected student achievement. Two NSF grants were awarded to the University of Wisconsin-Madison: first, to conduct a three-year study of the impact of *Mathematics in Context* on student mathematical performance (NSF Grant No. REC-9553889); and second, to analyze the data gathered in that study (NSF Grant No. REC-0087511). This monograph series presents the rationale, development, and conduct of the study of the implementation of the MiC materials in classrooms across the nation, and the results portray the impact of the use of that curriculum on student achievement.

As students and teachers begin to use any of the new mathematics materials, district administrators, mathematics educators, teachers, parents, and funding agencies express cogent needs to demonstrate that the curricula have a positive impact on students' understanding of mathematics. They often want to know the bottom line—the results on measures of achievement that confirm improved student mathematical performance. However, while improved student performance is critical, we contend that just relying on outcome measures to judge the impact of a standards-based program is insufficient. In fact, it is not enough to consider student outcomes in the absence of the effects of the culture in which student learning is situated, the instruction students experience, and their opportunity to learn comprehensive mathematics content in depth and with understanding. The dynamic interplay of all these variables has an impact on student learning, and as such, these variables must be considered in making judgments about the impact of any standards-based curriculum.

This monograph series tells the complex story of the variations in how the MiC materials were used by teachers and students in classrooms that vary in location and ecological culture, and the impact of that variation on the achievement of their students. The story unfolds in eight monographs. The titles of each monograph and the chapters in each are as follows:

L/CSS Monograph Series on the Impact of Teaching *Mathematics in Context* on Student Achievement

Monograph 1 Purpose, Plans, Goals and Conduct of the Study
- Chapter 1. Standards-Based Reform and *Mathematics in Context*
- Chapter 2. The Design of the Longitudinal/Cross-Sectional Study
- Chapter 3. Instrumentation, Sampling, and Operational Plan
- Chapter 4. Conduct of the Study

Monograph 2 Background on Students and Teachers
- Chapter 1. Background Information on Students at the Start of the Study
- Chapter 2. Information on Teacher Background Variables

Monograph 3 Instruction, Opportunity to Learn with Understanding, and School Capacity
- Chapter 1. The Quality of Instruction
- Chapter 2. Opportunity to Learn with Understanding
- Chapter 3. School Capacity

Monograph 4 Measures of Student Performance
- Chapter 1. Classroom Achievement
- Chapter 2. The Development of a Single Scale for Mapping Progress in Mathematical Competence

Monograph 5 The Impact of *Mathematics in Context* on Student Achievement
- Chapter 1. Grade-Level-by-Year Studies
- Chapter 2. Cross-Sectional Studies
- Chapter 3. Longitudinal Studies

Monograph 6 Differences in Performance Between *Mathematics in Context* and Conventional Students
- Chapter 1: Differences in Experimental Treatments and Units
- Chapter 2. Contrast Between MiC, MiC (Conventional), and Conventional Student Performance in the Cross-Grade and Cross-Year Studies
- Chapter 3. Contrast Between MiC and Conventional Student Performance in the Longitudinal Studies

Monograph 7 Differences in Student Performance for Three Treatment Groups
- Chapter 1. Overall Differences in Achievement for the Three Treatment Groups
- Chapter 2. Classroom Achievement of Comparable Classes
- Chapter 3. Other Results

Introduction to Monograph 2

This second monograph provides the background information about the participants in the study. In Chapter 1 information is provided about the students in the study. It includes information on fixed characteristics, mathematical knowledge, and disposition toward mathematics. This second monograph provides the background information about the participants in the study. In Chapter 1 information is provided about the students in the study. It includes information on fixed characteristics, mathematical knowledge, level of mathematical reasoning, and disposition toward mathematics. A measure of mathematical knowledge was derived from the standardized test that the District administered. The level of mathematical reasoning was determined for students when they completed the *Collis-Romberg Mathematical Problem Solving Profiles* (Collis & Romberg, 1992) at the start of the study. The disposition toward mathematics was determined from the students' responses to an attitude inventory that was developed for the study.

Then Chapter 2 contains information about the teachers in the study. This includes information about each teacher's background and experience, their prior experience teaching MiC, and their notions about teaching and learning mathematics prior to participating in the study.

CHAPTER 1: BACKGROUND INFORMATION ON STUDENTS AT THE START OF THE STUDY

Thomas A. Romberg and Mary C. Shafer

The purpose of this chapter is to summarize the information of the *Student Background* variables collected in 1997 on fifth-grade, sixth-grade, and seventh-grade classes at the beginning of the longitudinal/cross-sectional study of the impact of *Mathematics in Context* on student performance. The purpose of gathering this information was to describe similarities and differences in seven class characteristics prior to instruction (see Figure 1-1). Information on four fixed characteristics for the students in each class—gender, age, preferred language, and ethnicity—was gathered via a Student Questionnaire (Shafer, 1997a). Three other class characteristics—measures of student mathematical knowledge, student mathematical problem solving profiles, and disposition toward mathematics—were taken, respectively, from standardized test scores provided by the schools, scores on the project-administered *Collis-Romberg Mathematical Problem-Solving Profiles* (Collis & Romberg, 1992), and student responses to the Student Questionnaire and Student Attitude Inventory (Shafer, Wagner, & Davis, 1997). Districts are identified by number, and the classes by school and teacher (both pseudonyms). Also noted are the type of materials used (MiC materials or a conventional).

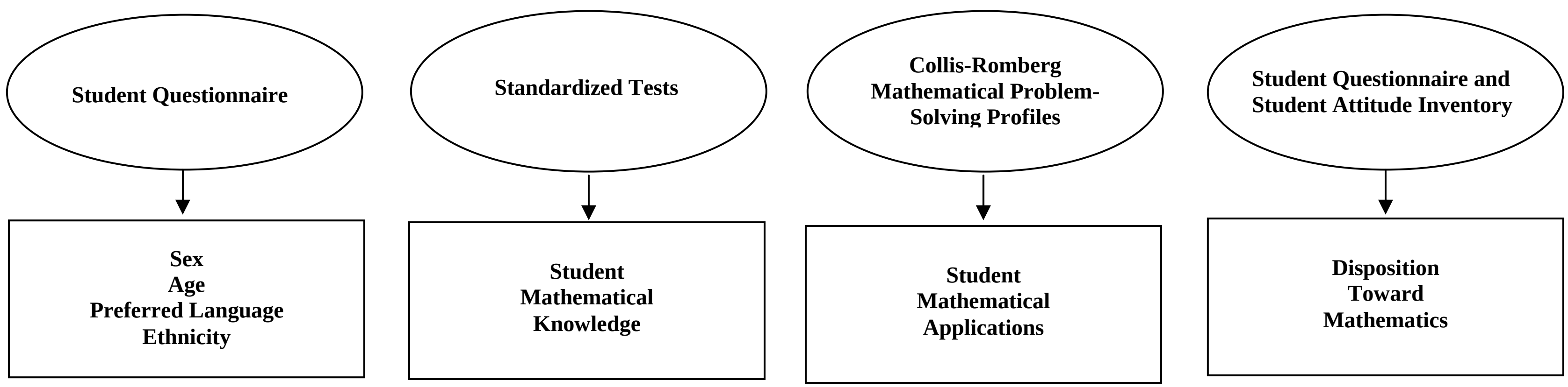


Figure 1-1. Fixed class characteristics in longitudinal/cross-sectional study of the impact of *Mathematics in Context* on student performance and their sources.

Fixed Characteristics

The data on three fixed characteristics (gender, age, and language preference) for the fifth, sixth, and seventh grade students are shown in Tables 1-1, 1-2, and 1-3.[1] Data for the other fixed characteristic *age* was collected for all students, and average class ages were calculated. However, since the average ages were so similar across classes in all districts, overall average ages for each district were not calculated. Overall the proportion of boys to girls was similar across districts, but the proportion of girls in conventional classes was considerably higher than for boys. English was the primary language for 72-96% of the students, and the ethnicity in these districts, as expected, varied considerably. District 1 has a White majority but with over 20% African American students. District 2 has a majority of Hispanic and Multiracial/Other students. District 3 has mostly White students. And, District 4 has a large majority of African American and Multiracial/Other students.

[1] These data are summarized from data reported in Romberg, Folgert, Shafer, & Arauco, 2001, 2002 and Romberg, Folgert, Shafer, Arauco, & Dremock, 2001.

Table 1-1

Fixed Characteristics of Grade 5 Students in 1997-1998

District	Program	*(N)*	Sex *(%)*		Language Preference *(%)* *		Ethnicity *(%)***				
			Female	**Male**	**English Preference**	**Non-Response**	**African American**	**Hispanic**	**White**	**Multi/Other**	**Non-Response**
District 1											
	Total	225	48	52	94	1	23	6	52	15	4
	MiC	170	49	51	96	1	26	6	50	13	5
	Conventional	55	45	55	89	2	13	5	58	20	4
District 2											
	Total	267	47	53	84	4	4	42	22	21	11
	MiC	192	49	51	83	5	5	49	20	20	5
	Conventional	75	41	59	87	3	1	24	28	21	25
District 3											
	Total	132	48	52	95	2	0	3	79	17	2
	MiC	132	48	52	95	2	0	3	79	17	2
	Conventional	-									
District 4											
	Total	0%	0	0	0	0	0	0	0	0	0
	MiC	0%	0	0	0	0	0	0	0	0	0
	Conventional	-									
Grade 5											
	Total	624	48	52	90	3	10	21	45	18	7
	MiC	494	49	51	90	3	11	22	46	17	4
	Conventional	130	43	57	88	2	6	16	41	21	16

* Percent does not add to 100% when students identified a language preference other than English.

** Percent on ethnicity was rounded off and does not always total 100. Multi/Other comprises Asian, Hatian, Native American, Multiratial and Other.

Table 1-2

Fixed Characteristics of Grade 6 Students in 1997-1998

District	Program	(N)	Sex (%)		Language Preference (%) *		Ethnicity (%)**				
			Female	Male	English Preference	Non-Response	African American	Hispanic	White	Multi/Other	Non-Response
District 1											
	Total	328	48	52	88	3	25	5	52	8	10
	MiC	237	51	49	88	4	22	6	55	5	13
	Conventional	91	41	59	88	2	34	3	43	18	2
District 2											
	Total	251	55	45	83	4	14	46	13	22	5
	MiC	185	59	41	85	4	11	50	16	20	3
	Conventional	66	44	56	82	3	23	35	6	27	9
District 3											
	Total	162	53	47	93	6	0	3	89	6	2
	MiC	162	53	47	93	6	0	3	89	6	2
	Conventional	-	-	-	-	-	-	-	-	-	-
District 4											
	Total	81	51	49	93	0	48	14	5	32	1
	MiC	81	51	49	93	0	48	14	5	32	1
	Conventional	-	-	-	-	-	-	-	-	-	-
Grade 6											
	Total	822	51	49	88	4	19	18	43	14	6
	MiC	665	54	46	89	4	17	18	46	13	6
	Conventional	157	42	58	85	3	29	17	27	22	5

* Percent does not add to 100% when students identified a language preference other than English.

** Percent on ethnicity was rounded off and does not always total 100. Multi/Other comprises Asian, Hatian, Native American, Multiratial and Other.

Table 1-3

Fixed Characteristics of Grade 7 Students in 1997-1998

District	Program	*(N)*	Sex *(%)*		Language Preference *(%)* *		Ethnicity *(%)***				
			Female	**Male**	**English Preference**	**Non-Response**	**African American**	**Hispanic**	**White**	**Multi/Other**	**Non-Response**
District 1											
	Total	219	54	46	93	1	18	6	61	11	5
	MiC	124	52	48	94	2	15	9	57	12	7
	Conventional	95	57	43	93	1	22	2	65	8	2
District 2											
	Total	271	50	50	87	4	15	46	13	18	7
	MiC	207	50	50	88	2	10	47	15	20	7
	Conventional	64	48	52	84	8	31	44	6	11	8
District 3											
	Total	134	43	57	72	1	0	1	91	7	1
	MiC	134	43	57	72	1	0	1	91	7	1
	Conventional	-	-	-	-	-	-	-	-	-	-
District 4											
	Total	152	51	49	80	13	22	24	3	38	14
	MiC	152	51	49	80	13	22	24	3	38	14
	Conventional	-	-	-	-	-	-	-	-	-	-
Grade 7											
	Total	776	50	50	85	4	15	23	38	18	7
	MiC	617	49	51	84	4	12	24	37	20	7
	Conventional	159	53	47	89	4	26	19	42	9	4

* Percent does not add to 100% when students identified a language preference other than English.

** Percent on ethnicity was rounded off and does not always total 100. Multi/Other comprises Asian, Hatian, Native American, Multiratial and Other.

In each district the information on the four fixed characteristics was calculated for the students in each class[2]. For example, in District 2 the fixed characteristics for the 10 sixth-grade classes in Year 1 of the study are shown in Table 1-4. Clearly there is significant variation in the class profiles on both gender and ethnicity. In fact, Hirsch Metro Middle School has almost all Hispanic students, while Guggenheim Middle School and Newberry Middle School have a mixture of African-American, Hispanic, and White students. Class profiles at other districts and at different grade levels, while not as striking as this example, also indicate considerable variability is class size, gender, and ethnicity.

Table 1-4
Fixed Characteristics of Grade 6 Students in 1997-1998, in District 2

School-Class *(N)*	**Sex *(%)***		**Average Age *(years)***	**Language Preference *(%)* ***		**Ethnicity *(%)*** *(self-identified)***				
	Female	**Male**		**English Preference**	**Non-Response**	**African American**	**Hispanic**	**White**	**Multi/Other**	**Non-Response**
—MiC—										
Guggenheim-Broughton 1 (26)	46	54	11.93	69	15	27	31	19	15	8
Guggenheim-Broughton 2 (14)	36	64	11.79	79	14	36	21	36	7	0
Guggenheim-Dillard 1 (27)	67	33	11.36	96	4	11	19	37	30	4
Guggenheim-Dillard 2 (16)	63	38	11.35	94	0	13	31	25	25	6
HirschMetro-Davenport 1 (22)	68	32	11.73	100	0	0	68	0	32	0
HirschMetro-Davenport 2 (26)	58	42	11.71	85	0	4	69	4	23	0
HirschMetro-Holland 1 (27)	70	30	11.72	81	0	4	81	0	11	4
HirschMetro-Holland 2 (27)	59	41	11.54	78	4	4	63	15	15	4
—Conventional—										
Newberry-Renlund 1 (29)	45	55	11.56	76	3	14	38	10	34	3
Newberry-Rhaney 1 (37)	43	57	11.75	86	3	30	32	3	22	14

* Percent does not add to 100% when students identified a language preference other than English.
** Percent on ethnicity was rounded off and does not always total 100. Multi/Other comprises Asian, Haitian, Native American, Multiracial and Other.

[2] Data for all grade 5 classes in the study is available in Working Paper No. 18a, (Romberg, Folgert, Shafer, Arauco, & Dremock, 2001). Data for all grade 6 classes in the study is available in Working Paper No. 18b, (Romberg, Folgert, Shafer, Arauco, & Dremock, 2001). And, data for all grade 7 classes in the study is available in Working Paper No. 18c, (Romberg, Folgert, Shafer, Arauco, & Dremock, 2001).

Summary

Given the variation in ethnicity across districts, and in both gender and ethnicity across classes within districts, the appropriate unit of analysis to determine the impact of using *Mathematics in Context* on student performance is the classroom nested within schools.

Student Mathematical Knowledge

Rather than imposing an additional form of standardized testing explicitly for study purposes, the research team asked districts to provide standardized test information they already collected and used in this study. The information that was provided on this characteristic was the percentile rankings for each student. The schools provided these rankings for the students in the study prior to the start of the study and for each of the following years.

The principle reason for collecting and using this information was to match the MiC and conventional students and their classes on the percentiles at the start of the study. Since random assignment of students, or classes, to treatments was impractical by having such information we could be aware of, and take into account, initial differences. Percentile scores were used as a means of examining results across the various tests. The assumption being was that study classes were comparable to the groups on which the norm-referenced scoring was formulated.

Each of the four school districts administered a norm-referenced standardized test to all of its students each year of the study. The specific tests varied among the districts and in some cases across years within districts. In the spring of 1997 Districts 1 and 3 the used was the *TerraNova* (CTB/McGraw-Hill, 1997), District 2 used the *Stanford Mathematics Achievement Test* (Harcourt Brace Educational Measurement, 1997), and District 4 used the *California Achievement Test* (CTB/McGraw-Hill, 1992). The limitation of using scores from several tests was that data were not available by item. Thus, comparisons for various content strands between standardized tests and study assessments were not possible. However, we felt that standardized test scores used as indicators of student achievement prior to the study, and as indicators of student performance outcomes to confirm the information derived from study assessments. The following information is a summary of all the information on the total students by district in the spring prior to the start of the study.

Results, Spring 1997

<u>Grade 5</u> The mean percentiles for students in the three districts with Grade 5 students is shown in Table 1-5. An initial examination of this table shows three striking features. First, there is no appreciable difference in overall means across the three districts. Each district's mean (and median) percentile is above average (over 50). Second, the within district variation on each test is

huge: individual percentiles range from 1 to 99 and all the district standard deviations are above 25. Third, the mean percentiles for the conventional students in both Districts 1 and 2 are considerably higher than the mean percentiles for the MiC students.

Table 1-5

Standardized Test Mean National Percentile for Grade 5 Students in Spring 1997, by District and Overall

District	Program	National Percentile					
		(N)	Mean	StDev	Minimum	Median	Maximum
District 1							
	Test	TerraNova					
	Total	197	63.94	26.25	4	69	99
	MiC	146	58.71	26.96	4	61	99
	Conventional	51	78.92	16.88	27	84	99
District 2							
	Test	Stanford Achievement Test					
	Total	202	62.42	26.59	1	66	99
	MiC	151	58.00	27.17	1	60	99
	Conventional	51	75.49	19.87	24	82	99
District 3							
	Test	TerraNova					
	Total	115	56.98	25.12	5	56	99
	MiC	115	56.98	25.12	5	56	99
	Conventional	-	-	-	-	-	-
Grade 5							
	Total	514	61.78	26.22	1	65	99
	MiC	412	57.97	26.48	1	58.5	99
	Conventional	102	77.21	18.42	24	82	99

To examine the differences between MiC and conventional students in more detail the Grade 5 class mean percentiles are reported for the classes in Districts 1 and 2[3]. The means and standard deviations of the percentiles for each class in District 1 are reported in Table 1-6, and box plots are shown in Figure 1-2. Clearly, the classes differed in average percentiles on this test. Mean percentiles ranged from 24.09 to 92.37, and the box plots illustrate the vast between-class variation on this test in this district. In fact, it appears that the three classes at Beethoven Middle School are tracked since the "boxes" in the plots do not overlap. Similarly, while there is some overlap of the "boxes" for the five classes at Dewey Middle School there is a distinct rank order to the classes, with the highest distribution of percentile rankings being in a conventional class, and the lower four distribution of scores in MiC classes.

Table 1-6
Standardized Test National Percentile Means for Grade 5 Students in District 1, Spring 1997 by Class

School-Class *(N)*	TerraNova National Percentile					
	(*N*)	**Mean**	**StDev**	**Minimum**	**Median**	**Maximum**
—MiC—						
Banneker-Greene 1 (22)	15	52.53	18.50	21	52	79
Beethoven-Kipling 1 (26)	25	70.76	14.27	44	70	95
Beethoven-LaSalle 1 (33)	30	92.37	5.88	78	94	99
Beethoven-Linne 1 (13)	11	24.09	12.49	9	26	44
Dewey-Hamilton 1 (21)	18	50.28	18.13	8	49.5	79
Dewey-Mitchell 1 (18)	16	64.88	18.97	38	66	97
Dewey-Mitchell 2 (19)	14	39.29	17.51	18	39	75
Dewey-Mitchell 3 (18)	17	28.53	16.13	4	25	64
—Conventional—						
Dewey-Kershaw 1 (24)	21	73.57	19.81	27	74	99
River Forest-Fulton 1 (31)	30	82.67	13.61	44	86.5	99

[3] Similar data for all grade 5 classes in the study is available in Working Paper 18a (Romberg, Folgert, Shafer, Arauco, & Dremock, 2001).

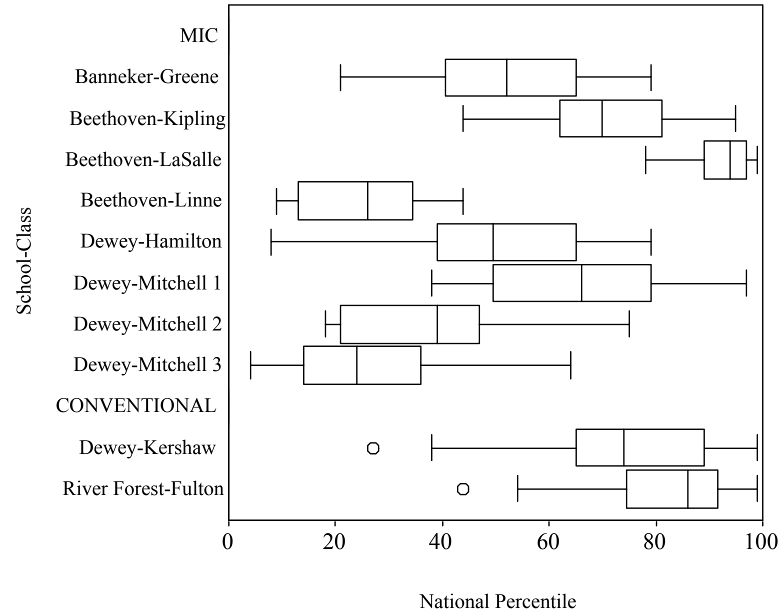


Figure 1-2. Box plots of class distributions on the *TerraNova,* Grade 5, District 1, Spring 1997.

Means and standard deviations of the percentiles for each class in District 2 are reported in Table 1-7, and box plots are shown in Figure 1-3. Again the classes differed in average percentiles on this test. Mean percentiles ranged from 47.08 to 75.52, and the box plots illustrate the between-class variation on this test in this district. In contrast to the class data for District 1, the limited range of class means, the very large within-class variation, and the considerable overlap of the “boxes” indicate that these are heterogeneously grouped classes. Furthermore, the differences between MiC and conventional classes appears to be related to school differences.

Table 1-7

Standardized Test National Percentile Means for Grade 5 Students in District 2, Spring 1997 by Class

School-Class *(N)*	SAT Applications: National Percentiles					
	(*N*)	**Mean**	**St Dev**	**Minimum**	**Median**	**Maximum**
—MiC—						
Armstrong-Murphy 1 (34)	25	68.24	23.32	10	70	99
Armstrong-Nash 1 (29)	23	63.43	23.13	19	63	99
Ogden-Fiske 1 (30)	25	51.36	28.35	8	43	93
Ogden-Fiske 2 (24)	13	47.08	24.23	8	50	86
Ogden-Piccolo 1 (27)	22	53.95	31.85	3	58	99
Ogden-Piccolo 2 (23)	20	59.05	26.01	12	63	93
Ogden-Piccolo 3 (25)	23	57.78	29.45	1	53	99
—Conventional—						
VonSteuben-Gant 1 (28)	23	75.52	19.73	35	82	99
VonSteuben-Gant 2 (27)	28	75.46	20.35	24	82	99

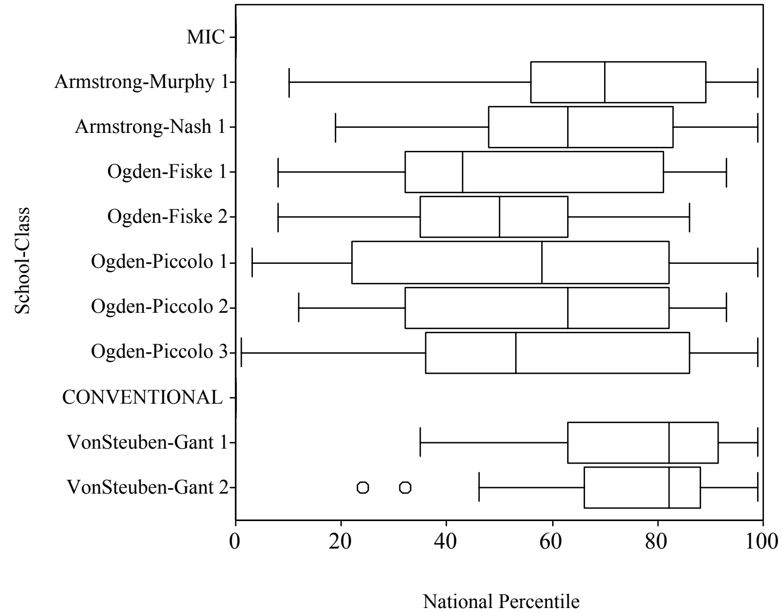


Figure 1-3. Box plots of class distributions on the *SAT Applications*, Grade 5, District 2, Spring 1997.

Grade 6 The mean percentiles for students in the four districts at Grade 6 is shown in Table 1-8. An initial examination of this table shows that in contrast to Grade 5 the mean percentiles across districts differ with District 4 having the highest mean (65.1) and District 1 being below average (44.04). As was the case at Grade 5, the within district variation on each test is very large. Also, the conventional students in District 1 have somewhat lower mean percentiles than the MiC students.

Table 1-8

Standardized Test National Percentile Means for Grade 6 in Spring 1997, by District and Overall

District	Program	National Percentile (N)	Mean	StDev	Minimum	Median	Maximum
District 1							
	Test			TerraNova			
	Total	229	44.04	23.8	1	44	94
	MiC	175	46.07	24.44	1	46	94
	Conventional	54	37.48	20.42	1	36.5	94
District 2							
	Test			Stanford Achievement Test			
	Total	216	53.43	27.63	1	57	99
	MiC	159	53.61	27.29	1	57	99
	Conventional	57	52.93	28.81	2	57	99
District 3							
	Test			TerraNova			
	Total	150	51.99	24.53	1	53.5	97
	MiC	150	51.99	24.53	1	53.5	97
	Conventional	-	-	-	-	-	-
District 4							
	Test			California Achievement Test			
	Total	78	65.31	22.6	15	67.5	99
	MiC	78	65.31	22.6	15	67.5	99
	Conventional	-	-	-	-	-	-
Grade 6							
	Total	673	51.29	25.9	1	51	99
	MiC	562	52.45	25.71	1	54	99
	Conventional	111	45.41	26.14	1	45	99

To examine these differences summary means and standard deviations of the percentiles for each class in District 1 are reported in Table 1-9, and box plots are shown in Figure 1-4[4]. The classes differed in average percentiles on this test. Mean percentiles ranged from 29.29 to 59.00, and the box plots illustrate the between-class variation on this test in this district. The limited range of class means, the very large within-class variation, and the considerable overlap of the "boxes" indicate that these are heterogeneously grouped classes. Furthermore, the differences between MiC and conventional classes probably are related to school differences.

Table 1-9
Standardized Test National Percentile Means for Grade 6 in Spring 1997 in District 1

School-Class *(N)*	***TerraNova***					
	National Percentile					
	(*N*)	**Mean**	**StDev**	**Minimum**	**Median**	**Maximum**
—MiC—						
Fernwood-Lee/Weatherspoon 1 (28)	22	39.27	20.57	12	36	86
Fernwood-Lee/Weatherspoon 2 (28)	20	42.55	26.42	12	34.5	92
Fernwood-Lee/Weatherspoon 3 (25)	19	59.00	28.82	10	73	88
VonHumboldt-Brown 1 (23)	15	44.87	22.42	7	46	91
VonHumboldt-Brown 2 (19)	14	29.29	17.20	11	28	59
VonHumboldt-Brown 3 (29)	18	49.00	25.84	5	50.5	89
VonHumboldt-Harvey 1 (28)	22	46.05	19.26	15	48	81
VonHumboldt-Harvey 2 (26)	23	53.17	28.32	9	60	94
VonHumboldt-Harvey 3 (32)	22	46.59	21.25	1	49.5	83
—Conventional—						
Addams-Tallackson 1 (20)	11	43.27	29.3	6	41	94
Wacker-Krittendon 1 (26)	14	39.86	15.81	8	42	66
Wacker-Krittendon 2 (23)	13	35.15	17.14	1	35	55
Wacker-Krittendon 3 (21)	16	33.31	19.92	10	27	83

[4] Working Paper 18b (Romberg, Folgert, Shafer, Arauco, & Dremock, 2001) contains this data.

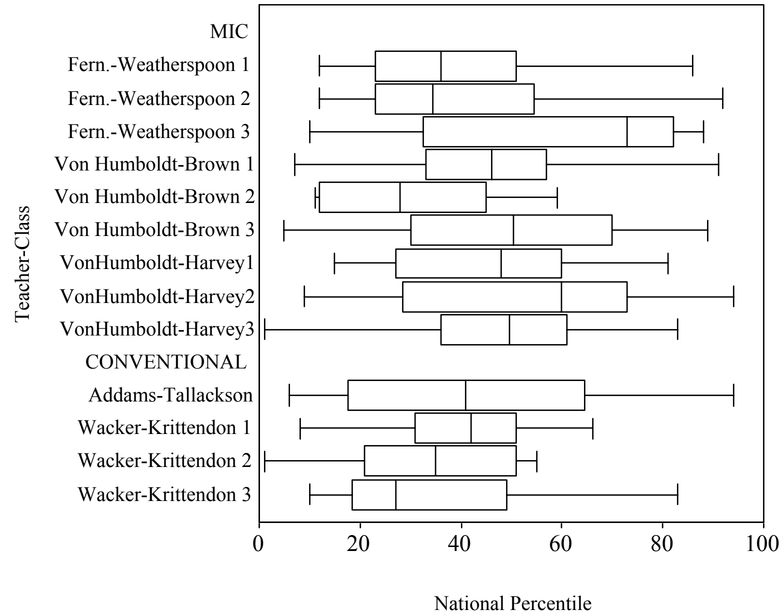


Figure 1-4. Box plots of class distributions on the *TerraNova* test, Grade 6, District 1, Spring 1997.

Grade 7 The mean percentiles for students in the four districts at Grade 7 are shown in Table 1-10. An initial examination of this table shows that the mean percentiles across districts differ with District 3 having a high mean (69.73) and both District 1 (48.57) and District 2 (42,75) being below average. As was the case at Grades 5 and 6, the within district variation on each test is very large. Also, the conventional students in District 2 have lower mean percentiles than the MiC students.

Table 1-10

Standardized Test National Percentile Means for Grade 7 in Spring 1997, by District and Overall

District	Program	National Percentile					
		(N)	**Mean**	**StDev**	**Minimum**	**Median**	**Maximum**
District 1							
	Test	TerraNova					
	Total	174	48.57	25.61	1	46	97
	MiC	99	47.11	26.27	2	44	97
	Conventional	75	50.49	24.75	1	51	96
District 2							
	Test	Stanford Achievement Test					
	Total	214	42.75	24.45	1	40	98
	MiC	165	44.82	23.93	1	40	98
	Conventional	49	35.8	25.12	3	29	98
District 3							
	Test	TerraNova					
	Total	122	69.73	21.32	15	74	99
	MiC	122	69.73	21.32	15	74	99
	Conventional	-	-	-	-	-	-
District 4							
	Test	California Achievement Test					
	Total	123	56.8	25.49	2	58	99
	MiC	123	56.8	25.49	2	58	99
	Conventional	-	-	-	-	-	-
Grade 7							
	Total	633	52.28	26.28	1	54	99
	MiC	509	54.13	26.08	1	55	99
	Conventional	124	44.69	25.82	1	44.5	98

To examine this summary means and standard deviations of the percentiles for each class in District 2 are reported in Table 1-11, and box plots are shown in Figure 1-5[5]. The classes differed in average percentiles on this test. Mean percentiles ranged from 22.92 to 55.16, and the box plots illustrate the between-class variation on this test in this district. Overall, for the MiC classes the limited range of class means, the very large within-class variation, and the considerable overlap of the "boxes" indicate that these are heterogeneously grouped classes. However, the differences between MiC and conventional classes are related both to school differences, and the grouping of students at Newberry Middle School (Ms Cunningham's two classes are very low).

Table 1-11
Standardized Test National Percentile Means for Grade 7 in Spring 1997 in District 2

	SAT Applications: National Percentiles					
School-Class *(N)*	**(*N*)**	**Mean**	**St Dev**	**Minimum**	**Median**	**Maximum**
—MiC—						
Guggenheim-Keeton 1 (27)	22	50.86	23.24	16	51	98
Guggenheim-Keeton 2 (24)	20	48.40	23.88	8	44	91
Guggenheim-Teague 1 (27)	24	35.08	23.67	1	30	84
Guggenheim-Teague 2 (25)	21	43.85	23.1	4	40	77
HirschMetro-Draski 1 (26)	24	50.54	26.47	18	39.5	97
HirschMetro-Draski 2 (25)	14	37.07	26.99	6	28	96
HirschMetro-McFadden 1 (23)	20	42.60	21.41	13	41.5	82
HirschMetro-McFadden 2 (30)	26	46.00	22.29	10	47	89
—Conventional—						
Newberry-Cunningham 1 (15)	13	22.92	22.68	4	12	71
Newberry-Cunningham 2 (23)	17	24.00	14.72	3	20	50
Newberry-Stark 1 (26)	19	55.16	22.37	18	55	98

[5] Working Paper 18c (Romberg, Folgert, Shafer, Arauco, and Dremock, 2001) contains this data.

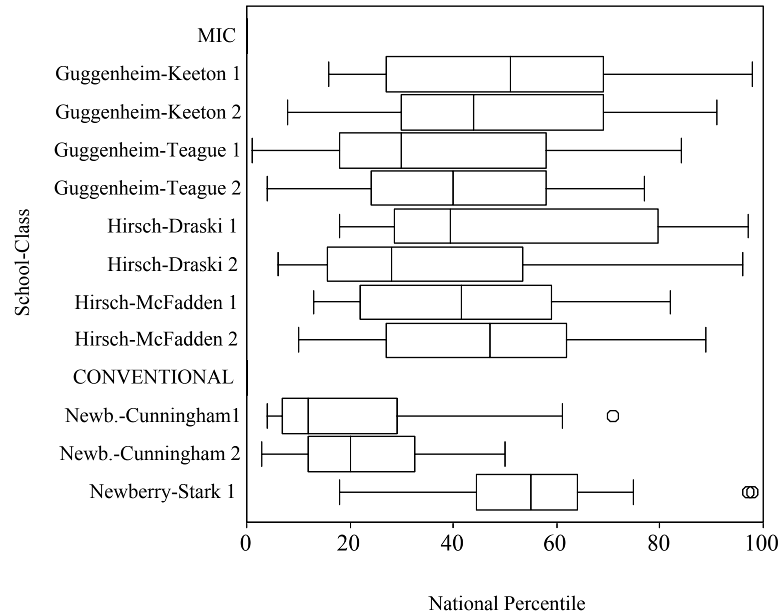


Figure 1-5. Box plots of class distributions on the *SAT Applications* test, Grade 7, District 2, Spring 1997.

Summary.

Because the districts give different tests and different forms of the standardized tests are used at different grade levels the inferences one can draw from this data are limited. However, three features of the data seem apparent. First, the within district variation of student percentiles at all grades is very large. Second, the across grade within district mean percentiles vary. In Districts 1 and 2 the Grade 5 student mean percentiles are considerably higher than in Grades 6 and 7; similarly in District 4 the Grade 6 mean percentile is higher that at Grade 7. However, in District 3 the mean percentile is quite a bit higher at Grade 7. Third, the overall MiC and Conventional populations in Districts 1 and 2 are not similar. Although we asked for heterogeneously grouped classes, this did not happen particularly in District 1. Also, for years 2 and 3 of the study standardized test data was collected during the prior spring[6]. For those years there is similar variation in mean percentile scores across districts, between schools within districts, and between classes within schools. Similarly, as with year 1 in some instances there are clear differences in percentiles between MiC and conventional classes.

Collis-Romberg Mathematical Problem Solving Profiles

Because the standardized tests varied by district, students completed the *Collis-Romberg Mathematical Problem Solving Profiles* (Collis & Romberg, 1992). Standardized test scores and profiles were used to compare students in both MiC and conventional classes in both cross-sectional and longitudinal analyses. The *Collis-Romberg Profiles* were used as a pre-test (Form A) in Year 1, and in the final spring of each student's participation (Form B) was administered as a post-test in the study. The *Collis–Romberg Mathematical Problem Solving Profiles* is a set of mathematical superitems designed to provide information about students' qualitatively different levels of reasoning ability. The format of the items was derived from what Cureton (1965) called "superitems". A problem situation (or stem) is then followed by a set of questions chosen to capture differences in the four of five structural levels of reasoning of the concrete symbolic mode.

The test used in this study contains five mathematical problem solving situations and four questions for each situation which were based on Collis and Biggs' (1979) SOLO taxonomy used to classify the structure of observed learning outcomes.

The SOLO Taxonomy

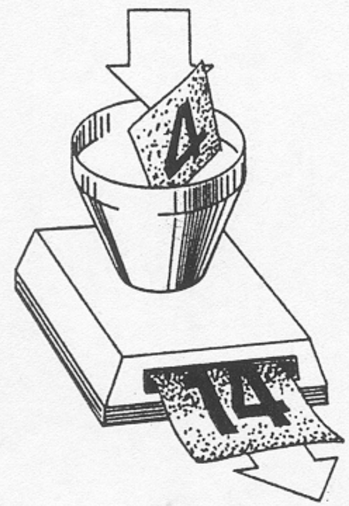
In the 1980's, several researchers (Biggs & Collis, 1982; Case, 1979; Fisher, 1980; Marton, 1981) devised similar models for the development of intellectual functioning in children and young adults. The model by Biggs and Collis, which they labeled, *Structure of the Learned Outcomes or Responses* (SOLO), provided the basic theoretical underpinning for developing the technique for assessing reasoning in this study. Biggs and Collis were concerned with describing the structure of any given response necessarily representing a particular stage of intellectual development. They proposed that the structure of the learned responses *within* each of four stages becomes increasingly complex. Their formulation is that *structurally* the complexities at each stage are the same: *prestructural* responses represent the use of no relevant aspect of the mode; *unistructural*, only one relevant aspect; *multistructural*, several disjoint aspects, usually in a sequence; *relational*, several aspects related into an integrated whole; and *extended abstract* takes the whole process into a higher mode of functioning.

[6] Working Papers 18a, b, c; 19a, b, c; 20 (Romberg, Folgert, Shafer, Arauco, and Dremock, 2001; Romberg, Folgert, Shafer, and Arauco, 2001, 2002) contain this data.

Students at the upper elementary and middle school level are hypothesized to be at what is called the "concrete operational level" and for mathematics. The *Collis-Romberg Mathematical Problem Solving Profiles* (Collis & Romberg, 1992) was designed to indicate a student's level of problem-solving ability in school mathematics at this level. This is done by posing a series of questions about four problems in such a way that each succeeding correct response would require a more sophisticated use of the information given than its predecessor. This increase in sophistication was designed to parallel the increasing complexity of structure noted in the SOLO categories.

An example of such a superitem is shown in Figure 1-6. The stem provides information, and each question that follows requires the student to reason at a different level in order to produce a correct response.

This is a machine that changes numbers. It adds the number you put in three times and then adds 2 more. So if you put in 4, it puts out 14.



U: If 14 is put out, what number was put in?
M. If we put in a 5, what number will the machine put out?
R. If we got out a 41, what number was put in?
E. If *x* is the number that comes out of the machine when the number *y* is put in, write down a formula that will give us the value of *y* whatever the value of *x*.

Figure 1-6. A superitem to reflect the SOLO taxonomy.

For this item in order to obtain a correct answer, the student would need to process the information in the stem in at least the following ways:

U (Answer: 4). One piece of information is used, one closure is required, and the information is obtainable from either the last sentence in the stem or the diagram—unistructural response level.

M (Answer: 17). All the information is used in a sequence of discrete closures; the stem is seen as a set of instructions to be followed in order—multistructural response level.

R (Answer: 13). All the information is used, but in addition the student has to extract the "principle" involved in the problem well enough to be able to use it in reverse; the student needs an overview of the instructions in the stem to carry out the appropriate operations—relational response level.

E (Answer: $y = (x-2)/3$). The student has to extract the abstract general principle from the information and write it in its abstract form, which involves dismissing distracting cues, perhaps forming hypotheses and testing them, and zeroing in on the relationships involved—extended abstract level.

The structure of the SOLO taxonomy assumes a latent hierarchical and cumulative cognitive dimension. Consequently, the response structure associated with any level of reasoning determines the response structure associated with all lower levels, in the sense that the presence of one response structure implies the presence of all lower response structures. The five expected response patterns for each of the superitems are shown in Table 1-12.

Table 1-12
Response Patterns for a SOLO Superitem

Response Pattern	SOLO Response Level			
	U	M	R	E
Pre-Structural	0	0	0	0
Uni-Structural	1	0	0	0
Multi-Structural	1	1	0	0
Relational	1	1	1	0
Extended Abstract	1	1	1	1

The aggregated scores of students on superitems corresponding to the four levels of reasoning in the SOLO taxonomy provide a basis for a possible natural arrangement of subjects into homogeneous groups. Note: If students are unable to answer questions at the uni-structural level, they are labeled as pre-structural. If a student is at a particular base stage of development, one would expect the average response pattern across several superitems to reflect that base stage of development. It would not be expected that the response patterns would be identical for every superitem since knowledge of prerequisites, familiarity, procedural errors, and so on are also operative. Furthermore, for a large number of students at any age level, one would expect that groups of students could be identified with similar response patterns for a set of items. It is plausible that the profiles of response patterns for the groups can be interpreted in terms of the SOLO taxonomy. The profiles which would be interpretable are based on the notions of equilibrations which involve "formation instability combined with a progressive movement toward stability" (Langer, 1969, p. 93).

For this study, we developed a profile for every student based on their responses to the questions on the *Collis-Romberg Profiles* instrument. Since the instrument was developed for diagnostic purposes, responses for each of the five superitems are coded in terms of correct (✓) or incorrect (X), the number of correct answers to each superitem, and a visual profile created with comments (see Figure 1-7).

COLLIS–ROMBERG MATHEMATICAL PROBLEM SOLVING PROFILES

INDIVIDUAL DIAGNOSTIC PROFILE

NAME: Mary SEX: F

AGE: 11 years 9 months DATE: 1/3/91

	U	M	R	E	Q1	Q2	Q3	Q4	Q5	
Q1	✓	✓	✓	✗	3					NUMBER
Q2	✓	✗	✗	✗		1				ALGEBRA
Q3	✓	✓	✗	✗			2			SPACE
Q4	✓	✗	✗	✗				1		MEASUREMENT
Q5	✓	✓	✗	✗					2	CHANCE AND DATA
	2				38	35	39	37	36	PAGE NUMBERS FOR FUTURE LEARNING
		2			44	40	45	43	41	
			1		50	47	51	49	48	
				0	52	52	52	52	52	

Q1 NUMBER SOLO Level U M [R] E

Comments:

Strongest area, shown by Relational response.

Q2 ALGEBRA SOLO Level [U] M R E

Comments:

Priority topic.

Q3 SPACE SOLO Level U [M] R E

Comments:

Appropriate for this age.

Q4 MEASUREMENT SOLO Level [U] M R E

Comments:

Priority topic.

Q5 CHANCE AND DATA SOLO Level U [M] R E

Comments:

Appropriate for this age.

OVER-ALL SOLO Level U [M] R E

Comments:

Algebra and Measurement need attention. Over-all Mary is performing at an appropriate level for her age.

Figure 1-7. Sample individual diagnostic profile.

Results: Fall Administration Year 1, 1997-1998

Grade 5. The percent of students at each level of reasoning in the three districts with Grade 5 student is shown in Table 1-13. An initial examination of this table shows that the average student in all three districts answers 3 of 5 questions at the unistructural level correctly, at least one multistructural question correctly, and is unlikely to answer questions correctly at either the relational or extended abstract levels correctly. Furthermore, while there is some variation an examination of between school within district and between class within school differences shows no apparent pattern of differences[7].

[7] Data for all grade 5 classes in the study is available in Technical Report No. 50 (Romberg, & Folgert, 2005).

Table 1-13

Collis-Romberg Profiles-Percent of Class at each Level, Grade 5, Fall 1997

District	Program	Level of Reasoning					
		(*N*)	Pre-structural	Uni-structural	Multi-structural	Relational	Extended Abstract
District 1							
	Total	213	19%	60%	20%	1%	0%
	MiC	162	23%	60%	16%	1%	0%
	Conventional	51	6%	59%	33%	2%	0%
District 2							
	Total	234	33%	59%	8%	0%	0%
	MiC	179	33%	59%	8%	0%	0%
	Conventional	55	18%	36%	2%	0%	0%
District 3							
	Total	129	31%	59%	9%	1%	0%
	MiC	129	31%	59%	9%	1%	0%
	Conventional	0	-	-	-	-	-
Grade 5							
	Total	576	27%	60%	13%	1%	0%
	MiC	470	29%	60%	11%	0%	0%
	Conventional	106	20%	59%	20%	1%	0%

Grade 6. The percent of students at each level of reasoning for in the three districts with Grade 6 student is shown in Table 1-14. An initial examination of this table shows that the average student in all three districts answers 3 of 5 questions at the unistructural level correctly, about one multistructural question correctly, and is unlikely to answer questions correctly at either the relational or extended abstract levels correctly. Surprisingly, these means are slightly lower than those for the Grade 5 students in the same districts. Furthermore, while there is some variation an examination of between school within district and between class within school differences shows no apparent pattern of differences[8].

[8] Data for all grade 6 classes in the study is available in Technical Report No. 50 (Romberg, & Folgert, 2005).

Table 1-14

Collis-Romberg Profiles-Percent of Class at each Level, Grade 6, Fall 1997

District	Program	Level of Reasoning					
		(*N*)	Pre-structural	Uni-structural	Multi-structural	Relational	Extended Abstract
District 1							
	Total	286	37%	55%	8%	1%	0%
	MiC	203	32%	60%	7%	1%	0%
	Conventional	83	48%	43%	8%	0%	0%
District 2							
	Total	206	35%	54%	10%	0%	0%
	MiC	163	34%	58%	8%	0%	0%
	Conventional	43	42%	37%	19%	2%	0%
District 3							
	Total	142	18%	63%	18%	1%	0%
	MiC	142	18%	63%	18%	1%	0%
	Conventional	-	-	-	-	-	-
District 4							
	Total	80	36%	59%	5%	0%	0%
	MiC	80	36%	59%	5%	0%	0%
	Conventional	-	-	-	-	-	-
Grade 6							
	Total	714	32%	57%	10%	1%	0%
	MiC	588	30%	60%	10%	1%	0%
	Conventional	126	46%	41%	12%	1%	0%

Grade 7. The means at each level of reasoning for students in the three districts with Grade 7 student is shown in Table 1-15. An initial examination of this table shows that the average student in all three districts answers most of the 5 questions at the unistructural level correctly, one or more multistructural question correctly, is likely to answer one question correctly at the relational level, but not at the extended abstract levels. Furthermore, while there is some variation an examination of between school within district differences, and between class within school differences were shows no apparent pattern of differences[9].

[9] Data for all grade 5 classes in the study is available in Technical Report No. 50 (Romberg, & Folgert, 2005).

Table 1-15
Collis-Romberg Profiles-Percent of Class at each Level, Grade 7, Fall 1997

District	Program	Level of Reasoning					
		(*N*)	Pre-structural	Uni-structural	Multi-structural	Relational	Extended Abstract
District 1							
	Total	202	25%	59%	13%	3%	0%
	MiC	112	23%	62%	12%	4%	0%
	Conventional	90	27%	56%	16%	2%	0%
District 2							
	Total	233	28%	66%	6%	0%	0%
	MiC	186	26%	68%	6%	1%	0%
	Conventional	47	36%	60%	4%	0%	0%
District 3							
	Total	126	10%	53%	28%	9%	0%
	MiC	126	10%	53%	28%	9%	0%
	Conventional	-	-	-	-	-	-
District 4							
	Total	130	26%	56%	14%	4%	0%
	MiC	130	26%	56%	14%	4%	0%
	Conventional	-	-	-	-	-	-
Grade 7							
	Total	691	23%	60%	13%	3%	0%
	MiC	554	22%	60%	14%	4%	0%
	Conventional	137	30%	57%	12%	1%	0%

Summary

Overall the results on this test were disappointing. Overall, the profiles across all grades were low. As a diagnostic instrument it may have been proven to be useful in examining an individual student's level of reasoning, but as an instrument to gage group differences it did not prove to be that helpful. To demonstrate this fact we examined the percent of students at the unistructural level for District 1 in Table 1-16 and the scatter plot relating the class mean unistructural scores and the class mean percentiles shown in Figure 1-7.

Table 1-16

Collis-Romberg Profiles--Percent of Class at each Level, Grade 5, Fall 1997 in District 1

School-Class *(N)*	**Level of Student Performance**					
	(N)	**Prestructural**	**Unistructural**	**Multistructural**	**Relational**	**Extended Abstract**
—MiC—						
Banneker-Greene 1 (22)	19	26%	53%	21%	0%	0%
Beethoven-Kipling 1 (26)	24	33%	50%	17%	0%	0%
Beethoven-LaSalle 1 (33)	32	6%	53%	38%	3%	0%
Beethoven-Linne 1 (13)	13	46%	54%	0%	0%	0%
Dewey-Hamilton 1 (21)	20	30%	60%	10%	0%	0%
Dewey-Mitchell 1 (18)	18	6%	72%	22%	0%	0%
Dewey-Mitchell 2 (19)	18	6%	94%	0%	0%	0%
Dewey-Mitchell 3 (18)	18	44%	56%	0%	0%	0%
—Conventional—						
Dewey-Kershaw 1 (24)	21	14%	57%	29%	0%	0%
River Forest-Fulton 1 (31)	30	0%	60%	37%	3%	0%

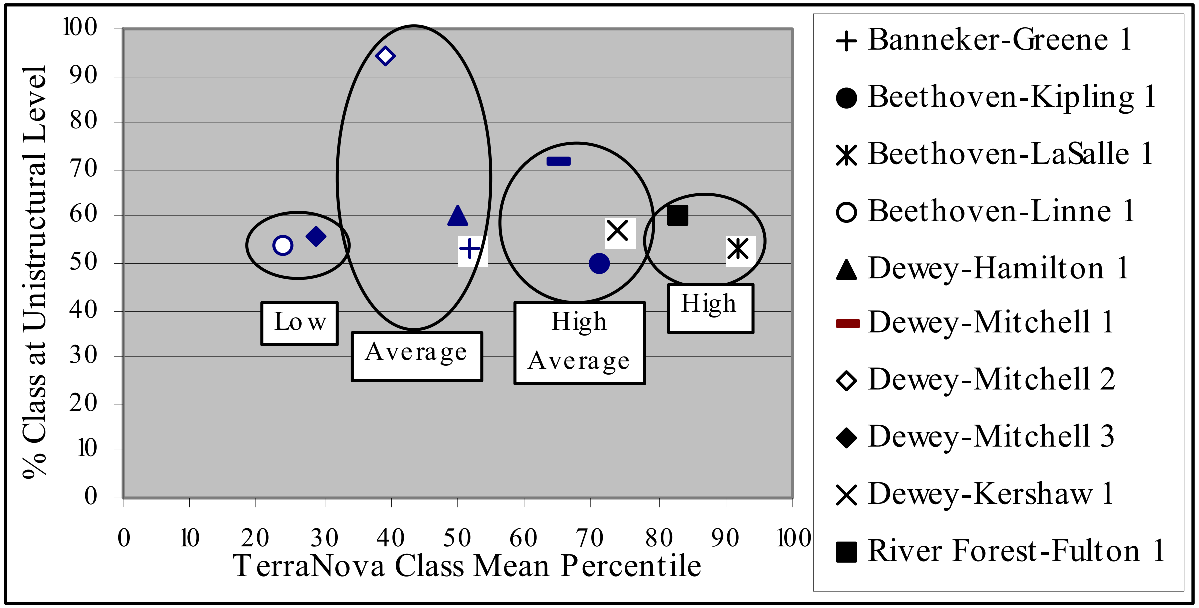


Figure 1-8. Scatter plot for class mean percentiles on the TerraNova and the percent of students at the unistructural level of the Collis-Romberg Mathematical Problem-Solving Profiles, Grade 5, District 1.

Student Attitude Inventory

In the structural research model for the longitudinal/cross-sectional study, *attitude* is both a background variable and an outcome variable that is influenced by a student's background and another outcome variable *knowledge and understanding of mathematics* (see Monograph 1, Chapter 2). In turn, as an outcome variable *attitude* affects the student's *knowledge and understanding of mathematics*, *application of mathematics*, and *further pursuit in mathematics*. In the study, *attitudes* are characterized as positive or negative feelings about the discipline of mathematics and about self and others as learners of mathematics. Attitudes are moderately intense and reasonably stable whereas beliefs are primarily cognitive in nature and develop over long periods (McLeod, 1992, p. 580). Students' attitudes are affected by the social norms of the communities in which they live and learn (Cobb, 1986; Hart & Walker, 1993; Leder, 1987; McLeod, 1992). Students develop attitudes toward mathematics, or strands of the mathematics curriculum, as they participate in instruction that repeatedly involves the same kinds of tasks and classroom interaction. The feelings experienced by students as they work on instructional tasks may influence their performance on those tasks.

Prior research on student attitudes suggests that attitudes may be considered as both input and outcome variables because various attitudes, including those related to confidence, self-efficacy, enjoyment, and usefulness of mathematics, correlate highly with student achievement (Beaton et al, 1996; Dossey, Mullis, Gorman, & Latham, 1994; Ma & Kishor, 1997; McLeod, 1992). Students who have higher achievement in mathematics report more positive attitudes toward mathematics, and those who report more positive attitudes display higher achievement in mathematics. More recently, research using longitudinal data and causal modeling suggests that students' achievement exhibits causal predominance over attitudes (Ma & Xu, 2004). That is, students' achievement has a direct impact on their attitudes toward mathematics.

Various studies of student attitudes have included interviews with elementary school children (Kloosterman & Cougan, 1994; Kloosterman, Raymond, & Emenaker, 1996); studies of attribution of success and failure (Fennema & Sherman, 1976a, b); studies of high school and college students (Kloosterman & Stage, 1992; Schoenfeld, 1989); studies using existing databases of longitudinal data (Ma & Xu, 2004); and studies of national and international samples gathered over multiple years (e.g., Dossey, Mullis, Gorman, & Latham, 1994; Schmidt et al, 1998). To varying degrees, students believe mathematics to be difficult and rule based. They believe mathematics problems should be solved in short periods of time, typically less than five minutes, through application of rules and memorized facts. Students agree that mathematics is useful for solving everyday problems and that most people use mathematics in their careers. They enjoy mathematics, although their enjoyment of mathematics appears to crest in their elementary school years and steadily decline thereafter. In international studies, U. S. students reported that mathematics was enjoyable but boring. Like students in other studies, students believed that with hard work, they can succeed in mathematics.

Much research on attitudes was conducted when students experienced conventional mathematics curriculum and instruction. However, recommendations in the *Curriculum and Evaluation Standards* (NCTM, 1989) and the *Professional Standards for Teaching Mathematics* (NCTM, 1991) advocate problem solving, reasoning, and communication in algebra, geometry, probability and statistics in addition to number—changes that are likely to have an impact on student attitudes. McLeod (1988) commented, "There is nothing wrong with the students' mechanism for developing beliefs about mathematics; what needs to be changed is the curriculum (and beyond that, the culture) that generates such beliefs" (p. 69). Few studies have examined students' attitudes as they study a reform-oriented curriculum such as MiC. For example, Clarke, Wallbridge, & Fraser (1992) found that high school students who studied the Interactive Mathematics Project materials, a reform-oriented curriculum that emphasized problem solving, small group work, and classroom discussion, were more likely to view mathematics as a creative endeavor than students studying conventional algebra texts. They also valued classroom communication more than students experiencing traditional curriculum and instruction. In case study research, Shew (1996) reported that, after one year of studying MiC field-test units, fifth-grade students changed their beliefs about mathematics and mathematics teaching and learning. This change in beliefs had an impact on classroom interaction:

> As they broadened their beliefs about mathematical topics, the students began to use their mathematical knowledge and relate it to the real world. They moved from passively listening in class to actively listening and/or observing others, and then owning what others said by rephrasing it in their own words and explaining it to others. They offered a variety of solution strategies to any given problem and they looked critically at the mathematics, questioning what did not make sense to them. (p. 204)

The Student Attitude Inventory (SAI) for the MiC longitudinal/cross-sectional study was designed to take reform-oriented goals into consideration in characterizing the attitudes of middle-school students toward mathematics and toward themselves as learners of mathematics (Shafer, Wagner, & Davis, 1997). The SAI contains two sections: statements rated on a Likert scale and open-response items. The first section is a set of statements written to reflect students' attitudes and beliefs about mathematics and to themselves as learners of mathematics. The statements are grouped into seven subscales: effort to succeed in mathematics, interest in and excitement about mathematics, confidence in learning mathematics, communication of mathematical ideas, usefulness of mathematics, general perceptions about mathematics and learners of mathematics, and attribution of success and failure in perceptions of mathematics. The second section is a set of four open-response items that elicit students' description of mathematics, their beliefs about occupations that use mathematics, and ways they use mathematics outside of school.

Development of the Student Attitude Inventory

The Likert statements in the SAI are collections of items used in previous research on student attitudes (Dossey, Mullis, Gorman, & Latham, 1994; Fennema & Sherman, 1976a; Kloosterman & Stage, 1992; Schoenfeld, 1989). These items were reworded to update the terminology and to facilitate use with younger audiences than those for which they were originally used. New statements were also written to reflect current constructs of import in the reform movement, such as technology, communication, and collaboration. Attitudes were characterized through related but contradictory statements. For example, the effort subscale includes the following statements: "If I don't understand a math problem, I give up without trying very hard to figure it out" and "If I have trouble figuring out a problem right away, I don't like to stop working on it until I get an answer that makes sense." Negative statements in the first five subscales are reverse-scored. Thus, ratings on two related but contradictory statements are expected to result in similar scores. The results for all items in a particular scale can be aggregated to check for general trends in student data, to check measures of reliability, and to determine consistency of student responses. Statements were separated into seven categories: effort to succeed in mathematics, interest in and excitement about mathematics, confidence in learning mathematics, usefulness of mathematics, communication of mathematical ideas, general perceptions about mathematics and mathematics learning, and attribution of success and failure in studying mathematics.

Description of Subscales

Effort to succeed in mathematics. In their synthesis of the effect of motivation on achievement in mathematics, Middleton & Spanias (1999) concluded that when students think that their ability in mathematics can be changed through effort, they tend to apply more effort in learning mathematics. Kloosterman & Cougan (1994) found that most fifth- and sixth-grade students in their sample believed that students who expended effort would succeed in learning mathematics. In international studies, U. S. students were more likely to believe in the effectiveness of hard work in learning mathematics than students in other countries (Schmidt et al., 1998). The effort subscale of the SAI measured students' beliefs that with sufficient effort, any person could learn mathematics and improve his/her mathematical abilities (see Shafer, Wagner, & Davis, 1997).

Interest and excitement about mathematics. Although many beliefs and attitudes that students hold appear to encumber students' curiosity about and understanding of mathematics, some attitudes appear to result in students' increased interest in learning the subject (Kloosterman & Stage, 1992). Furthermore, students who were interested in mathematics were also confident in their abilities to succeed in mathematics. Interests in mathematics, however, varied widely by grade level, declining as grade levels increased (Kloosterman & Cougan, 1994). The decline in student enjoyment of mathematics was also noted in National Assessment of Educational Progress (NAEP), which is disconcerting in light of findings that students with more positive attitudes were higher in achievement (Dossey et al., 1994). The interest subscale of the SAI measured students' enjoyment of learning mathematics (see Shafer, Wagner, & Davis, 1997).

Confidence in learning mathematics. Confidence can be described as "a belief about one's competence in mathematics" (McLeod, 1992, p. 583). In the *Curriculum and Evaluation Standards* (1989), the NCTM included "becoming confident in one's own mathematical abilities" as one of the five general goals for students in developing their mathematical power. Confidence and achievement appear to be related. Particularly at the high school level, research suggests that there is a strong, positive correlation between confidence and achievement in mathematics (Reyes, 1984). Schoenfeld (1989) noted that this correlation has been documented consistently in research studies beginning with the National Longitudinal Study of Mathematical Abilities (Crosswhite, 1972). If students are confident about their mathematical abilities or motivated, for example, by the view that mathematics skills are valuable, they are more likely to engage in and persist in solving nonroutine tasks for which no prescribed method or procedure is immediately evident. In contrast, if students lack confidence in their problem-solving skills, see no relevance in mathematics, or, for example, believe that mathematics problems should be solved easily in five minutes or less, their ability to solve nonroutine problems may be compromised. Kloosterman and Stage (1992) maintained that "good problem solvers must be motivated to solve problems for which there are no memorized rules to follow" (p. 110). Moreover, students who believe it is important to know why a procedure works will take the time to understand it or to invent their own algorithms. These students "will know they can learn mathematics and thus will be motivated to try to learn" (Kloosterman & Stage, 1992, p. 110). The confidence subscale of the SAI measured students' confidence in their abilities to learn mathematics and perform well on mathematical tasks (see Shafer, Wagner, & Davis, 1997).

Usefulness of mathematics. Dossey et al. (1994) cited two indicators of the value of mathematics to students: student perceptions of the relevance of mathematics to their daily lives and their perceptions of the usefulness of mathematics in obtaining jobs. Belief that mathematics is useful or relevant to daily life appears to be a particularly strong motivator. Students who agreed with statements that indicated that mathematics was pertinent and useful in obtaining jobs showed higher mathematics performance (Brown et al., 1988; Dossey et al., 1994; Fennema & Sherman, 1986). In the *Curriculum and Evaluation Standards* (1989), NCTM included "learning to value mathematics" as one of the five general goals for students in developing their mathematical power. The usefulness subscale of the SAI measured students' beliefs about the relevance of mathematics to daily life and about the usefulness of mathematics in helping people to acquire and succeed in jobs (see Shafer, Wagner, & Davis, 1997).

Communication of mathematical ideas. The context in which the learning is situated affects the attitudes of the learners. In classrooms, social norms negotiated by teacher and students influence the patterns of classroom interactions. Expectations for students to provide explanations for their solutions and to answer questions from others open possibilities for students to rethink their ideas in order to clarify their reasoning for others (Yackel, Cobb, Wood, Wheatley, & Merkel, 1990). Teacher's use of questions can influence students' attitudes about mathematics by focusing questions on the interpretation of a problem context, justification of strategies, making connections among representations, and flexibility demonstrated by solving a problem in a different way (Confrey, 1990; Stenmark, 1991; Streefland, 1992). The communication subscale of the SAI measured students' beliefs about the importance of communication in developing mathematical understanding, both for the individual and for shared understanding in the classroom community. The subscale also measured students' beliefs about the teacher's interest in student ideas about mathematical content (see Shafer, Wagner, & Davis, 1997).

General perceptions about mathematics and mathematics teaching and learning. The general perceptions subscale measured attitudes related to calculator use, the nature of mathematics (problem solving versus facts or rules), the learning of mathematics (importance of understanding a concept versus getting a correct answer), and connections of mathematics to other school subjects (see

Shafer, Wagner, & Davis, 1997). Two items per construct were included to ensure consistency of student responses (e.g., “Knowing how to solve a problem is as important as getting the answer” and “Answering questions correctly in math means only giving a number”). Taken together, the 16 statements form a profile of a student’s general conceptions of mathematics. The results for this subscale cannot be aggregated across items. Because the individual statements cover a wide range of tangentially related conceptions, a mean score for the subscale is not meaningful. Rather, results are described for pairs of complementary statements.

Attribution of success and failure in studying mathematics. The attributions subscale measured students’ beliefs about the internal factors (ability and effort) or external factors (teacher and luck) that influenced their success and failure in mathematics (Fennema & Sherman, 1976a, b; see Shafer, Wagner, & Davis, 1997). This subscale is composed of 10 items in four categories. Two items per category are included to ensure consistency of student responses (e.g., “When I do well in math, it’s because the teacher likes me” and “When I don’t do well in math, it’s because the teacher doesn’t like me”). Negative statements are not reverse-scored because the response to a particular item indicates whether the student attributes success or failure in mathematics to a particular cause. For two related items, one coded for success and one coded for failure, the scores are expected to similar. Aggregating the results into a mean score for the subscale does not yield meaningful results.

Validity and Reliability

Initially, 75 statements reflecting the attitudes represented in the seven subscales were written. Nine educators (classroom teachers, professors, and graduate research assistants) then sorted the statements into subscales. Statements were retained in their initial subscale when reviewers reached 79% or more agreement. Items with less than 79% agreement were reworded, moved to a different subscale, or dropped. This process resulted in retaining 65 statements. Statements were randomly distributed throughout the SAI, with efforts made to avoid using items from the same subscale in succession. Following Schoenfeld (1989), each statement is accompanied by a 4-point Likert scale indicating student level of agreement: Very True, Sort of True, Not Very True, Not True at All. Students had relatively low scores if their responses reflected a positive attitude and relatively high scores if their responses reflected a negative attitude.

In the second section of the SAI, four open-ended items are included for students to provide more extensive answers on their ideas about mathematics and its uses outside of school: words students associated with the word mathematics; two items related to occupations besides teaching that students thought required the use of mathematics; and ways students used mathematics outside of class. The SAI was pilot-tested with elementary- and middle-school classes using reform-based mathematics curricula or conventional curricula. A time limit was not given for completing the inventory; administration typically took between 20 and 30 minutes. Reliability (Cronbach’s alpha) of the subscales and inter-item correlations were calculated for each subscale after particular items were removed from it. As a result, the inventory was pared down to 60 statements. With respect to the open-response items, students were able to provide meaningful answers. Consequently, those items remained unchanged after pilot-testing.

Overall Results: Fall Administration Year 1

The overall data about student responses to the Student Attitude Inventory are shown in Table 1-17. The means for the total population on all five subscales at the start of the study were similar and very positive, the standard deviations were minimal, and the reliabilities of the scales reasonable given the number of items in each subscale.

Table 1-17
Means, Standard Deviations, and Reliabilities (Cronbach's ∂) on Subscales

Scale	N	Mean (S.D.)	Cronbach's ∂
Effort	1760	1.85 (.55)	.63
Confidence	1811	1.93 (.55)	.60
Interest and Excitement	1743	2.02 (.70)	.86
Usefulness of Mathematics	1708	1.75 (.51)	.64
Communication	1741	1.87 (.49)	.63

The correlations between the five subscales are shown in Table 1-18. All correlations are positive and statistically significant. This indicates significant colinearity. However the values (between .47 and .60) indicate that each subscale provides a unique contribution to the overall construct of student attitudes toward mathematics.

Table 1-18
Inter-Scale Correlation or Independence of the Scales

	Effort	Confidence	Interest	Usefulness	Communication
Effort					
Confidence	.53*				
Interest	.60*	.55*			
Usefulness	.52*	.52*	.55*		
Communication	.50*	.47*	.48*	.48*	

*significant at p<.05

A contrast in the overall means and standard deviations for students in the two treatment groups, MiC and conventional, are shown in Table 1-19, showing that there are no real differences on any of the five subscales between the two groups of students at the start of the study.

Table 1-19
Means and Standard Deviations on Subscales by Treatment

	All Students		MiC Students		Conventional	
Scale	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Effort	1760	1.85(.55)	1444	1.84 (.55)	316	1.90 (.55)
Confidence	1811	1.93(.55)	1492	1.94 (.56)	319	1.88 (.55)
Interest	1743	2.02(.70)	1429	2.04 (.70)	314	1.91 (.65)
Usefulness	1708	1.75(.51)	1409	1.75 (.50)	299	1.73 (.52)
Communication	1741	1.87(.49)	1430	1.87 (.49)	311	1.87 (.50)

The response data on the sixteen items on the General Perception subscale are shown in Table 1-20 for the total population and for the two treatment groups. Overall, the students were confident they could learn mathematics, could solve problems, and recognized the importance of effort. However, they were very ambivalent in their responses to all other questions. Also, there were only three significant differences in the responses between the two treatment groups. The conventional students were more positive on two items, (3. I feel sure that I am able to learn new ideas in mathematics), and (44. When my teacher asks a question I will get it right if I have memorized the correct rule or fact). And the MiC students were more positive on one item (16. It's OK if I solve a math problem differently than my classmates do). Although overall the differences between the two treatment groups are small these three significant differences clearly reflect the stereotypic differences between conventional and reform instruction.

Table 1-20

Means and Standard Deviations on General Perception Questions by Treatment

	All Students		MiC Students		Conventional	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Confidence						
3.	1888	1.45 (.69)	1548	1.47 (.71)	340	1.35* (.60)
Problem Solving						
4.	1919	1.67 (.81)	1569	1.66 (.81)	350	1.71 (.83)
16.	1926	1.36 (.66)	1574	1.35** (.64)	352	1.45 (.74)
Effort						
11.	1908	1.24 (.60)	1561	1.23 (.59)	347	1.28 (.65)
37.	1892	2.91 (1.05)	1556	2.93 (1.05)	336	2.82 (1.04)
Mathematics Learning						
53.	1860	1.56 (.83)	1529	1.56 (.83)	331	1.56 (.85)
38.	1886	1.73 (.93)	1549	1.73 (.92)	337	1.73 (.94)
Importance of Understanding						
27.	1900	2.34 (1.16)	1555	2.34 (1.16)	345	2.31 (1.17)
49.	1862	2.01 (.1.09)	1531	2.02 (1.09)	331	1.94 (1.05)
Nature of Mathematics						
55.	1858	2.84 (1.00)	1529	2.86 (1.00)	329	2.75 (.98)
44.	1874	3.11 (.90)	1538	3.13 (.90)	336	2.98* (.90)
Calculator Use						
45.	1863	2.78 (1.04)	1530	2.80 (1.04)	333	2.71 (1.03)
6.	1914	2.60 (1.03)	1566	2.62 (1.03)	348	2.54 (1.00)
Connections to Other Subjects						
20.	1917	1.77 (.98)	1568	1.77 (.97)	349	1.74 (.99)
39.	1864	2.35 (1.01)	1530	2.37 (1.00)	334	2.30 (1.05)
28.	1914	2.46 (1.05)	1567	2.46 (1.05)	347	2.46 (1.06)

*significant at $p<.01$

**significant at $p<.05$

Finally, the means and standard deviations for the responses for the overall population and for the two treatment groups on the *Attribution of Success and Failure* items are shown in Tables 1-21 and 1-22. Overall, students strongly attribute both success and failure to effort, and both are not attributed to either teachers or luck. Attribution of ability to success is positive and to failure is negative. The only significant differences between the groups on these items indicates that while both groups indicates that ability does not contribute to failure, the conventional students are more convinced of that than the MiC students.

Table 1-21
Attribution of Success and Failure

Attribution	Success		Failure	
	N	Mean (SD)	N	Mean (SD)
Teacher	1911	3.58 (.80)	1888	3.64 (.78)
Ability	1910	2.26 (.99)	1917	2.97 (1.03)
Effort	1880	1.35 (.71)	1844	1.99 (.98)
Luck	1907	3.19 (.97)	1862	3.45 (.88)

Table 1-22
Attribution of Success and Failure By Treatment

Attribution	MiC Students				Conventional			
	N	Success Mean (SD)	N	Failure Mean (SD)	N	Success Mean (SD)	N	Failure Mean (SD)
Teacher	1563	3.59 (.79)	1549	3.65 (.77)	348	3.52 (.85)	339	3.57 (.85)
Ability	1567	2.26 (1.00)	1568	2.93* (1.04)	343	2.25 (.98)	349	3.15 (.96)
Effort	1546	1.34 (.70)	1520	1.99 (.99)	334	1.40 (.72)	324	1.95 (.93)
Luck	1565	3.17 (.98)	1532	3.46 (.87)	342	3.28 (.96)	330	3.41 (.91)

*significant at p<.01

Summary

At the beginning of the study this data indicates that overall the students in the study were positive about mathematics and attributed success and failure to effort. Also, there were minimal differences between the two treatment groups.

Detailed Results from Year 1

The results for each subscale are illustrated with data from seventh-grade students in District 1.

On the first five subscales—effort to succeed in mathematics, interest in and excitement about mathematics, confidence in learning mathematics, usefulness of mathematics, communication of mathematical ideas—there were no real differences between students who used MiC and students who used conventional curricula at the start of the study, and class means were very similar across districts. Results from the seventh-grade classes in District 1 are used to illustrate these findings. The class means on the five subscales are shown in Table 1-23[10]. Each item was judged on a scale of 1–4 (1 = Very True; 2 = True; 3 = Not True; 4 = Not True at All).

[10] Student attitude data for all Year 1 classes in the study is available in Technical Report 18a, b, c (Romberg, Folgert, Shafer, Arauco, & Dremock, 2001; Shafer & Folgert, 2005).

Table 1-23
Class Means on Student Judgment About Mathematics (Subscales of the Student Attitude Inventory), Grade 7, District 1 in 1997

School-Class *(N)*	**Effort** *in mathematics*		**Confidence** *in ability to do mathematics*		**Interest** *in mathematics*		**Usefulness** *of mathematics*		**Ability to Communicate** *about mathematics*	
	(*N*)	Mean	(*N*)	Mean	(*N*)	Mean	(*N*)	Mean	(*N*)	Mean
—MiC—										
Fernwood-Heath 1 (30)	24	2.09	25	2.05	23	2.20	23	1.77	23	1.76
Fernwood-Heath 2 (23)	17	2.07	18	1.98	15	1.98	17	1.68	16	1.86
VonHumboldt-Donnely 1 (25)	11	1.80	12	1.98	12	2.25	11	1.86	12	2.08
VonHumboldt-Donnely 2 (23)	10	2.42	15	2.45	11	2.74	10	1.94	11	2.16
VonHumboldt-Donnely 3 (23)	18	2.10	18	2.02	18	2.32	17	2.03	18	2.03
—Conventional—										
Addams-St.James 1 (20)	19	2.11	19	1.92	18	2.19	18	1.78	18	1.85
Addams-St.James 2 (19)	17	1.98	18	1.84	18	2.08	18	1.69	18	1.82
Wacker-McLaughlin 1 (24)	20	2.03	21	1.79	20	2.08	19	1.76	20	2.03
Wacker-McLaughlin 2 (16)	12	2.01	10	2.04	11	2.26	11	1.85	12	1.86
Wacker-McLaughlin 3 (16)	10	1.53	10	1.64	10	1.71	9	1.46	10	1.84

Generally, among the seventh-grade students in District 1, there was little variation among classes. Students believed that they would succeed in mathematics class if they put forth the effort, and they felt confident in their abilities to do mathematics and communicate mathematically. Students were interested in mathematics, and they felt that mathematics was useful in their daily lives. Differences among the classes are displayed in Figure 1-9. One class, Wacker-McLaughlin 3, was more positive that with sufficient effort anyone can learn mathematics, and they were more confident and more interested in mathematics than other classes. Another class, Von Humboldt-Donnelly 2, was more negative that with sufficient effort anyone can learn mathematics and less confident in their ability to do mathematics and to communicate about mathematics than were students in the other classes.

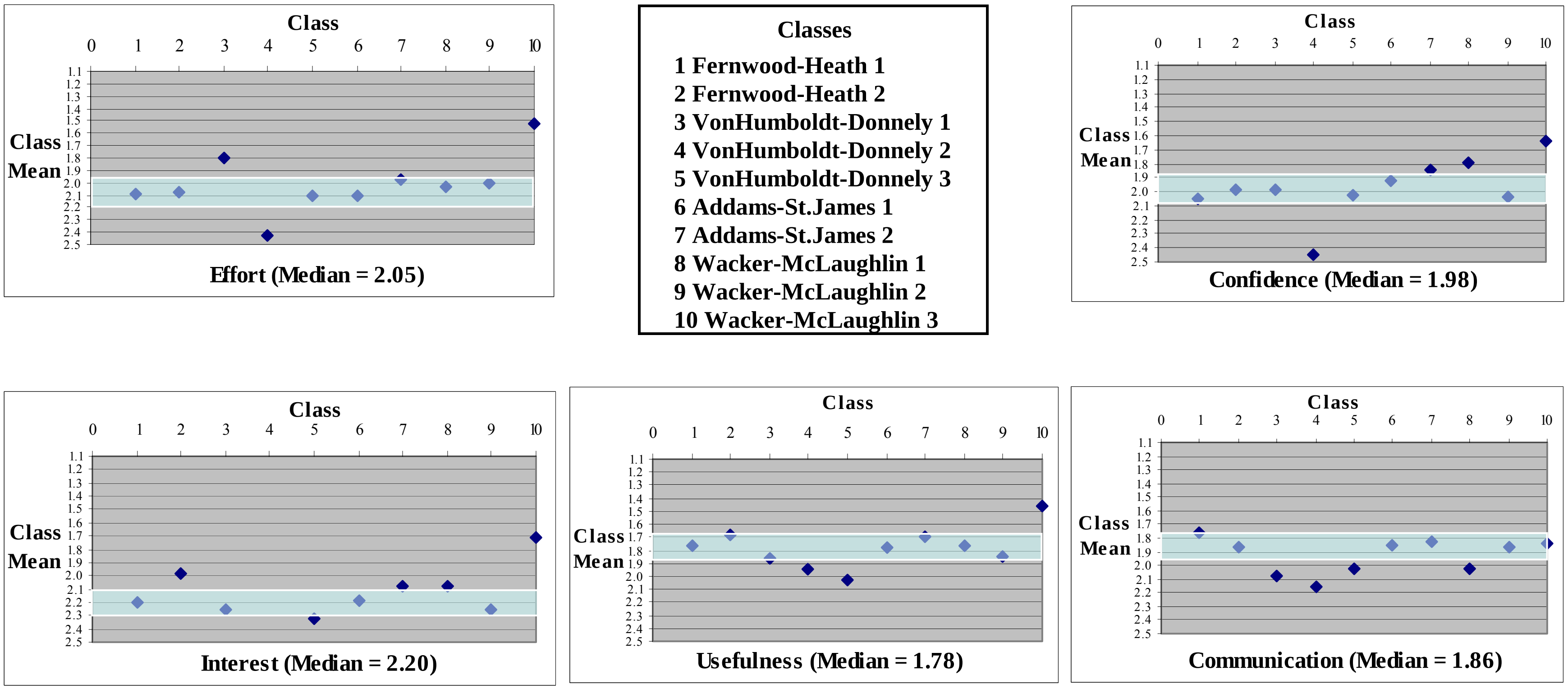


Figure 1-9. Plots showing class means on student judgments about mathematics, Grade 7, District 1. (Shaded areas show class medians ± 0.1.)

Differences in these five subscales were noted for fifth-grade students in Districts 1, 2, and 3 (all districts that had fifth-grade study students). The results for the fifth-grade students in District 1 are used to illustrate these differences. Fifth-grade students were far more positive in terms of interest in and excitement about mathematics (see Table 1-24). This finding correlates with previous research that students' interest in mathematics declines from elementary school through middle school. To a lesser degree, fifth-grade students were also more positive regarding their effort to succeed in mathematics, their confidence in learning mathematics, and their ability to communicate mathematical ideas. The two classes low on preceding achievement, Beethoven-Linne and Dewey-Mitchell 3, however, tended both to be less confident in their ability to do mathematics and tended to believe mathematics was less useful to them than did students in the other classes.

Table 1-24
Class Means on Student Judgments About Mathematics (Subscales on the Student Attitude Inventory), Grade 5, District 1 in 1997

School-Class *(N)*	**Effort** *in mathematics*		**Confidence** *in ability to do mathematics*		**Interest** *in mathematics*		**Usefulness** *of mathematics*		**Ability to Communicate** *about mathematics*	
	(*N*)	Mean	**(*N*)**	Mean	**(*N*)**	Mean	**(*N*)**	Mean	**(*N*)**	Mean
—MiC—										
Banneker-Greene (22)	15	1.59	17	1.80	15	1.60	15	1.67	16	1.82
Beethoven-Kipling (26)	23	1.60	21	1.69	23	1.53	23	1.43	20	1.59
Beethoven-LaSalle (33)	31	1.69	29	1.52	29	1.47	31	1.32	31	1.69
Beethoven-Linne (13)	10	1.77	12	2.07	10	1.55	11	1.83	10	1.73
Dewey-Hamilton (21)	19	1.53	20	1.61	20	1.66	18	1.44	19	1.68
Dewey-Mitchell 1 (18)	18	1.67	18	1.74	18	1.49	18	1.61	17	1.53
Dewey-Mitchell 2 (19)	12	1.53	17	1.79	17	1.44	16	1.59	14	1.60
Dewey-Mitchell 3 (18)	17	1.51	18	1.96	18	1.63	17	1.98	17	1.66
—Conventional—										
Dewey-Kershaw (24)	20	1.48	21	1.57	19	1.47	18	1.52	18	1.49
River Forest-Fulton (31)	28	1.61	29	1.49	29	1.55	28	1.38	29	1.74

The initial administration of the attitude inventory yielded no significant differences (based on independent samples t-test) in the means between the MiC and conventional classes on any of the subscales. That is, at the beginning of the longitudinal study, students' attitudes toward mathematics were comparable in both MiC classes and classes using conventional curricula.

General Perceptions Subscale

The general perceptions subscale measured attitudes related to calculator use, the nature of mathematics (problem solving versus facts or rules), the learning of mathematics (importance of understanding a concept versus getting a correct answer), and connections of mathematics to other school subjects. As noted above, the results are described for pairs of complementary statements because the individual statements cover a wide range of tangentially related conceptions. Overall, little variance was evident in class means. Regarding the nature of mathematics and mathematics learning, seventh-grade students in District 1 thought that mathematics was mostly learned by memorizing facts and rules (see Table 1-25). They also thought that they would get correct answers to their teachers' questions if they memorized rules or facts.

Table 1-25

Class Means on General Perceptions Items of the Student Attitude Inventory, Grade 7, District 1 in 1997

School-Teacher *(N)*	**Item Number *(see Key)***																							
	3			**4**			**6**			**11**			**16**			**20**			**27**			**28**		
	(N)	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**
—MiC—																								
Fernwood-Heath 1 (30)	26	1.65	0.94	26	1.46	0.86	26	2.00	0.94	26	1.38	0.90	26	1.15	0.37	26	1.46	0.90	26	2.50	1.14	26	2.46	1.03
Fernwood-Heath 2 (23)	20	1.45	0.51	21	1.67	0.80	21	2.38	1.12	21	1.29	0.46	21	1.48	0.93	20	1.50	0.76	21	2.33	1.02	21	2.62	0.97
VonHumboldt-Donnely 1 (25)	15	1.73	0.80	15	1.73	0.80	15	2.40	1.12	14	1.43	0.65	15	1.27	0.46	15	1.80	0.77	15	1.93	1.16	15	2.60	0.74
VonHumboldt-Donnely 2 (23)	18	1.94	0.80	17	1.88	0.78	18	1.94	0.80	18	1.39	0.78	18	1.39	0.50	18	1.78	1.00	17	2.59	1.00	16	2.94	0.93
VonHumboldt-Donnely 3 (23)	21	1.67	0.86	20	1.60	0.68	20	2.30	1.03	21	1.33	0.48	20	1.10	0.31	19	2.05	1.08	19	2.58	1.17	19	2.89	0.94
—Conventional—																								
Addams-St.James 1 (20)	18	1.28	0.46	19	1.95	0.62	19	2.16	0.96	19	1.42	0.61	19	1.68	0.82	19	1.37	0.68	19	1.79	1.08	19	2.68	0.89
Addams-St.James 2 (19)	18	1.44	0.62	18	1.89	0.90	18	2.44	0.98	18	1.11	0.32	19	1.32	0.58	19	1.26	0.56	19	1.68	0.89	19	2.47	1.07
Wacker-McLaughlin 1 (24)	22	1.45	0.74	22	1.68	0.78	22	2.27	0.98	22	1.55	0.96	22	1.50	0.74	22	1.59	1.05	22	2.45	1.10	22	2.05	1.25
Wacker-McLaughlin 2 (16)	11	1.45	0.52	12	1.83	0.72	12	2.92	1.16	12	1.50	0.80	12	1.25	0.45	11	1.91	1.04	11	2.64	0.92	12	3.00	1.13
Wacker-McLaughlin 3 (16)	11	1.36	0.50	11	1.45	0.52	11	2.64	0.92	11	1.36	0.92	11	1.27	0.47	11	1.64	0.81	11	2.27	1.10	11	1.91	1.38

School-Teacher *(N)*	**37**			**38**			**39**			**44**			**45**			**49**			**53**			**55**		
	(N)	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**	***(N)***	**Mean**	**StD**
—MiC—																								
Fernwood-Heath 1 (30)	26	2.85	1.12	26	1.77	0.99	25	2.40	0.91	26	3.27	0.87	26	2.96	1.08	26	1.88	0.99	26	1.62	0.94	26	2.58	1.21
Fernwood-Heath 2 (23)	21	2.67	0.91	20	1.85	1.04	20	2.35	1.04	18	3.33	0.84	18	2.33	1.08	18	1.94	1.00	19	2.00	0.82	19	2.89	0.81
VonHumboldt-Donnely 1 (25)	13	3.15	0.99	12	2.08	0.90	12	2.25	0.87	12	2.92	1.00	12	2.08	1.08	11	1.82	0.75	12	1.67	0.98	12	2.83	1.03
VonHumboldt-Donnely 2 (23)	15	3.13	0.74	15	1.73	0.80	15	1.93	0.88	12	3.00	0.95	11	2.64	1.29	11	2.27	1.10	11	1.55	0.69	11	2.73	1.10
VonHumboldt-Donnely 3 (23)	19	2.95	1.03	19	1.89	1.05	19	2.16	0.76	18	2.89	0.90	18	2.83	1.04	18	2.06	0.94	18	1.78	0.81	18	3.00	0.91
—Conventional—																								
Addams-St.James 1 (20)	19	2.58	0.96	19	1.53	0.70	19	2.16	0.90	19	2.79	0.63	19	2.32	1.00	19	1.74	0.93	19	1.63	0.76	18	2.78	0.65
Addams-St.James 2 (19)	19	2.58	1.22	19	1.47	0.61	19	2.16	0.96	19	3.00	1.00	19	1.95	0.91	19	1.74	0.93	18	1.56	0.92	19	2.89	0.81
Wacker-McLaughlin 1 (24)	22	2.95	1.17	22	1.41	0.73	21	1.86	1.20	22	3.00	1.02	22	2.45	0.86	21	1.90	1.00	20	1.80	1.06	21	2.57	0.93
Wacker-McLaughlin 2 (16)	12	3.50	0.80	12	2.00	1.04	12	2.58	1.08	12	2.92	1.08	11	2.55	0.93	12	2.75	1.14	12	1.50	0.67	12	2.75	0.87
Wacker-McLaughlin 3 (16)	10	2.60	1.07	10	1.20	0.63	10	1.70	0.48	10	3.30	0.48	9	2.22	1.09	10	1.40	0.97	10	1.40	0.52	10	2.40	1.17

(Table 1-25 *continued*)

Key

3. I feel sure that I am able to learn new ideas in math class. *(confidence in ability to learn mathematics)*
4. In mathematics, you can discover new ways of solving problems that the teacher or your classmates may not have thought of. *(problem solving)*
6.* If I use a calculator to solve a problem, I can be sure it will always give me the right answer. *(calculator use)*
11. Anyone who works hard enough can be good at math. *(effort)*
16. It's okay if I solve a math problem differently than my classmates do. *(problem solving)*
20.* Mathematics is not related to any of my other school subjects. *(connection to other school subjects)*
27.* Understanding why an answer is right is not as important as getting the right answer. *(understanding vs. answer)*
28.* Mathematics is more difficult to understand than other subjects. *(connection to other school subjects)*
37.* No matter how hard a person works, some people are just naturally good at math and some are just not. *(effort)*
38.* Answering questions correctly in math means only giving a number. *(process vs. answer)*
39.* Each new math topic I study is not related to ones I have learned before. *(connection among mathematics topics)*
44.* When my teacher asks a question I will get it right if I have memorized the correct rule or fact. *(mathematics as facts or rules)*
45.* If you have to use a calculator to solve a problem, you don't really understand how to do the problem. *(calculator use)*
49.* It really doesn't matter if you understand a math problem or how you get an answer as long as the answer you get is right. *(understanding vs. answer)*
53. Knowing how to solve a problem is as important as getting the answer. *(process vs. answer)*
55.* Mathematics is mostly learned by memorizing facts and rules. *(mathematics as facts or rules)*

* Reverse-scored due to wording of question.

Students felt that knowing how to solve a problem was as important as determining the answer, and they disagreed that answering questions correctly in mathematics class required providing only numbers. In terms of problem solving and understanding mathematics, students thought it was acceptable to solve mathematics problems differently than their classmates, and they were confident that they could discover ways of solving problems that their teachers or peers had not previously considered. Students were less convinced that getting correct answers in mathematics class was at least as important as understanding why the answers were correct. They were also less convinced of the necessity for a person to understand a mathematics problem or the process of finding an answer if the answer was correct. With respect to calculator use, students disagreed that if they used calculators they did not know how to solve mathematics problems, and they were not convinced that calculators always generated correct answers.

Students felt confident that they were able to learn new ideas in mathematics class, and they agreed that anyone who worked hard enough could be good at mathematics. They disagreed that some students were naturally better, or worse, than other students regardless of the effort they expended. Students were less convinced that new mathematics topics were related to ones they had already studied. Although they felt that mathematics was related to other school subjects, they thought that mathematics was harder to understand than other school subjects.

Some differences were noted for fifth-grade students in District 1. They were more positive than seventh-grade students that they were able to learn new ideas in mathematics class, that anyone who worked hard enough could be good at mathematics, and that mathematics is more difficult to understand than other subjects. Fifth-grade students were more convinced than seventh-grade students that getting correct answers in mathematics class was at least as important as understanding why the answers were correct, they disagreed more strongly that if they used calculators they did not know how to solve mathematics problems, and they were less convinced that calculators always generated correct answers.

Fifth- and seventh-grade students in classes with low preceding achievement in District 1 reflected attitudes shared by classes in other districts with low preceding achievement. They agreed with the following statements more than their peers:

- No matter how hard a person works, some people are just naturally good at math and some are just not.
- Understanding why an answer is right is not as important as getting the right answer.
- It really doesn't matter if you understand a math problem or how you get an answer as long as the answer you get is right.
- If I use a calculator to solve a problem, I can be sure it will always give me the right answer.
- Mathematics is not related to any of my other school subjects.
- Each new math topic I study is not related to ones I have learned before.

In general, students in classes with high levels of preceding achievement tended to disagree with the following statements more than their peers.

- Understanding why an answer is right is not as important as getting the right answer.
- It really doesn't matter if you understand a math problem or how you get an answer as long as the answer you get is right.
- When my teacher asks a question, I will get it right if I had memorized the correct rule or fact.
- Mathematics is mostly learned by memorizing facts and rules.
- Mathematics is not related to any of my other school subjects.

These attitudes reflect stereotypic responses for both low and high achieving students.

For the general perception subscale, means and standard deviations were calculated by type of curriculum for individual items in the general perceptions subscale. In two instances, significant differences (based on independent samples t-test) were noted in favor of students who are using MiC. For the statement "It's okay if I solve a math problem differently than my classmates do," students in MiC classes agreed more strongly than students using conventional curricula. For the statement "When my teacher asks a question, I will get it right if I had memorized the correct rule or fact," students in MiC classes disagreed more strongly than students using conventional curricula. For one statement, "I feel sure that I'm able to learn new ideas in math class," students using conventional curricula agreed more strongly with this statement than students using MiC. Although there are significant differences with respect to these three items, in general the groups of students were comparable at the beginning of the longitudinal study on the general perceptions subscale.

Attributions Subscale

In the attributions subscale, students' beliefs about the internal factors (ability and effort) or external factors (teacher and luck) that influenced their success and failure in mathematics were measured (Fennema & Sherman, 1976a, b; see Shafer, Wagner, & Davis, 1997). As noted above, negative statements were not reverse-scored because the response to a particular item indicates whether the student attributes success or failure in mathematics to a particular cause. The class means for seventh-grade students in District 1 are shown in Table 1-26. Students strongly felt that they did well in mathematics because they worked hard to succeed, although they were ambivalent about the role that their own natural abilities played in success in learning mathematics. Students did not attribute success in mathematics to being liked by their teachers or to luck. Students attributed failure in mathematics to a lack of hard work, rather than their teacher, their own natural ability, or luck.

Table 1-26

Class Means on Student Attribution of Success or Failure in Mathematics, Grade 7, District 1 in 1997

School-Class (*N*)	Teacher		Ability		Effort		Luck	
	(*N*)	Mean	(*N*)	Mean	(*N*)	Mean	(*N*)	Mean
Success								
—MiC—								
Fernwood-Heath 1 (30)	26	3.73	26	2.42	26	1.31	26	3.19
Fernwood-Heath 2 (23)	20	3.45	21	2.33	21	1.57	21	2.81
VonHumboldt-Donnely 1 (25)	15	3.47	15	2.07	12	1.50	13	3.08
VonHumboldt-Donnely 2 (23)	18	3.83	18	2.94	15	1.73	16	2.69
VonHumboldt-Donnely 3 (23)	21	3.19	21	2.29	19	1.84	19	2.58
—Conventional—								
Addams-St.James 1 (20)	19	3.79	19	2.53	19	1.37	19	3.42
Addams-St.James 2 (19)	17	3.71	18	2.61	19	1.42	19	3.53
Wacker-McLaughlin 1 (24)	22	3.55	22	2.41	21	1.67	22	3.55
Wacker-McLaughlin 2 (16)	12	3.58	12	2.92	12	1.33	11	3.27
Wacker-McLaughlin 3 (16)	11	3.45	11	2.27	10	1.30	10	3.50
Failure								
—MiC—								
Fernwood-Heath 1 (30)	26	3.62	26	2.96	26	2.08	26	3.58
Fernwood-Heath 2 (23)	20	3.60	20	3.10	18	2.22	19	3.47
VonHumboldt-Donnely 1 (25)	13	3.46	15	3.07	12	2.25	12	3.17
VonHumboldt-Donnely 2 (23)	15	3.53	17	2.82	11	2.09	11	3.00
VonHumboldt-Donnely 3 (23)	19	3.53	20	2.50	18	1.94	18	3.00
—Conventional—								
Addams-St.James 1 (20)	19	3.53	19	3.26	18	1.72	18	3.61
Addams-St.James 2 (19)	19	4.00	19	3.42	18	1.78	19	3.79
Wacker-McLaughlin 1 (24)	22	3.82	22	3.27	21	2.29	21	3.33
Wacker-McLaughlin 2 (16)	12	3.58	11	2.91	12	2.25	12	2.75
Wacker-McLaughlin 3 (16)	10	4.00	11	3.73	10	2.10	10	3.90

The consistency of the results for the attributions subscale across seventh-grade classes in this district is shown in Figure 1-10. It is clearly evident that students believe they control success in mathematics through the effort they expend in learning mathematics and to a lesser degree ability. In contrast, they indicated that the external factors of their teachers liking them and luck were not important. These results support Schoenfeld's (1989) findings in which students tended to characterize mathematics as an objective discipline that can be mastered through hard work more than through innate ability.

a) b)

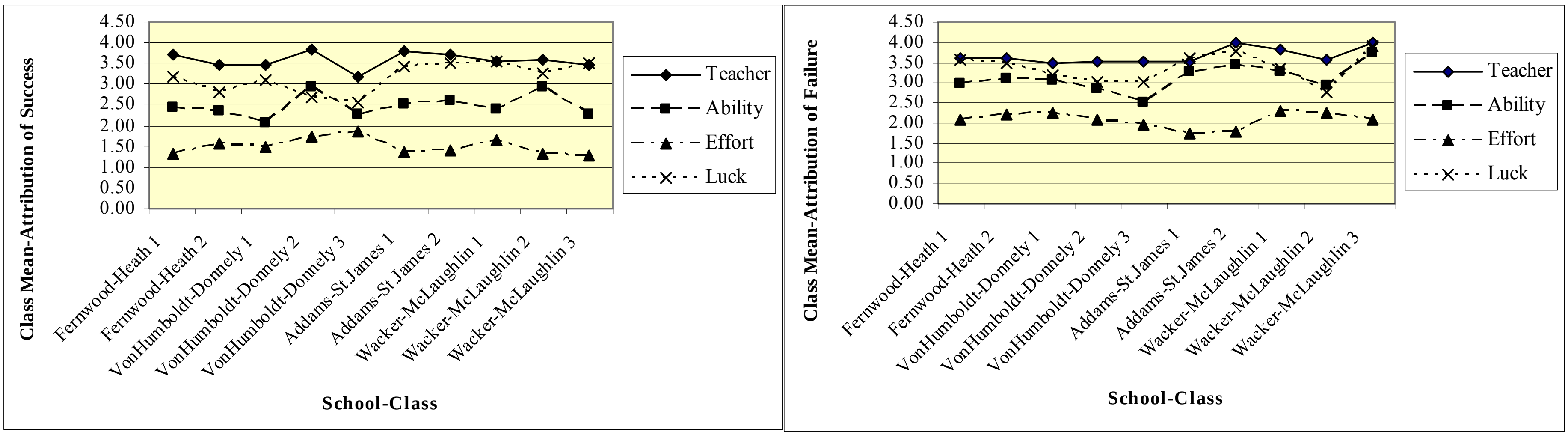


Figure 1-10. Line graphs showing class means of student attribution of (a) success and (b) failure in mathematics, Grade 7, District 1, in Fall 1998.

Fifth-grade students tended to more strongly attribute success in mathematics to ability, and in District 1, fifth-grade students more strongly felt that their success in mathematics was due to their natural abilities to do mathematics and to being liked by their teacher. Means and standard deviations were calculated by curriculum for individual items in the attribution subscale. The results indicate that students using MiC and students using conventional curricula are comparable with respect to attributions of success and failure with the exception of one item. For the statement "When I don't do well in math, it's because I'm not good at math," students who studied conventional curricula were more convinced that ability does not contribute to failure in learning mathematics.

Open-Response Items

Overall, students studying MiC or conventional curricula at different grade levels responded in similar ways to the open-response items on the SAI. When reporting things they associated with the word “mathematics,” seventh-grade students in District 1 most frequently listed words associated with number, including operations with numbers (see Table 1-27). In some classes, students listed words related to geometry, problem solving, and negative emotive words more than students in the other classes.

Table 1-27
Words Associated With "Mathematics," Grade 7, District 1 in 1997

School-Class *(N)*	**Number of Responses[1] *(N)***	**Number[2] *(%)*[3]**	**Interest *(%)***	**Geometry *(%)***	**Negative Emotive Responses[4] *(%)***	**Thinking *(%)***	**Problem Solving *(%)***	**Algebra *(%)***	**Occupations *(%)***	**Miscellaneous *(%)***
—MiC—										
Fernwood-Heath 1 (25)	99	42	3	14	11	6	5	2	0	5
Fernwood-Heath 2 (18)	70	57	4	11	0	4	6	1	0	6
VonHumboldt-Donnelly 1 (12)	38	50	0	11	16	0	5	3	0	5
VonHumboldt-Donnelly 2 (9)	35	51	0	9	0	0	11	3	0	20
VonHumboldt-Donnelly 3 (14)	51	76	0	0	6	2	4	0	0	8
—Conventional—										
Addams-St.James 1 (19)	76	61	3	0	1	3	4	7	0	17
Addams-St.James 2 (19)	113	52	0	7	2	5	9	7	0	15
Wacker-McLaughlin 1 (18)	82	77	1	2	2	0	5	5	0	4
Wacker-McLaughlin 2 (11)	47	74	0	0	6	4	2	0	2	9
Wacker-McLaughlin 3 (10)	51	71	0	0	2	0	8	8	6	4

[1] Students were asked to list the words they "think of when they hear the word mathematics."

[2] Responses included operations with numbers.

[3] Percentage does not add to 100 due to number of unique responses.

[4] Responses included "boring," "stupid," and statements of displeasure.

Students also reported their ideas about jobs other than teaching that required the use of mathematics. They most frequently listed service occupations, including retail sales, business, and food service, and frequently mentioned financial occupations, such as accounting, banking, and insurance (see Table 1-28). In some classes, students listed professional occupations including medical fields, engineering, and law more often than other students.

Table 1-28
Nonteaching Jobs that Students Identified as Requiring Mathematics, Grade 7, District 1 in 1997

School-Class *(N)*	**Number of Responses[1] *(N)***	**Services[2,3] *(%)***	**Financial[4] *(%)***	**Professional[5] *(%)***	**Science *(%)***	**Trades *(%)***	**Creative Arts *(%)***	**Government *(%)***	**Sports *(%)***	**Unreportable[6] *(%)***
—MiC—										
Fernwood-Heath 1 (25)	61	36	11	11	2	15	10	0	2	11
Fernwood-Heath 2 (18)	51	31	8	22	4	12	4	0	0	16
VonHumboldt-Donnelly 1 (12)	26	31	27	8	8	8	4	0	0	8
VonHumboldt-Donnelly 2 (9)	23	43	22	13	9	4	4	4	0	0
VonHumboldt-Donnelly 3 (14)	28	29	25	7	11	7	4	7	0	11
—Conventional—										
Addams-St.James 1 (19)	52	27	25	17	6	8	4	2	0	10
Addams-St.James 2 (19)	55	38	7	24	5	11	0	2	5	4
Wacker-McLaughlin 1 (18)	48	52	15	4	2	6	4	0	6	8
Wacker-McLaughlin 2 (11)	30	50	20	10	3	10	3	0	0	3
Wacker-McLaughlin 3 (10)	27	48	22	4	4	0	11	0	0	4

[1] Students were asked to list the jobs besides teaching that require mathematics.

[2] Percentage does not add to 100 due to number of unique responses.

[3] Responses included occupations in retail sales, business, and food service.

[4] Responses included occupations in accounting, banking, and insurance.

[5] Responses included occupations in medical fields, engineering, and law.

[6] Responses included teaching, thinking, and operations with numbers.

When reporting ways they used mathematics outside of class, students most frequently listed monetary uses, such as banking and shopping (see Table 1-29). Also, some classes more frequently listed uses of mathematics in calculation, leisure, and measurement than other students.

Table 1-29
Ways Students Used Mathematics Outside of Class, Grade 7, District 1 in 1997

School-Class *(N)*	**Number of Responses[1] *(N)***	**Monetary[2,3] *(%)***	**Calculation *(%)***	**Leisure *(%)***	**Measurement *(%)***	**Problem Solving *(%)***	**Unreportable[4] *(%)***
—MiC—							
Fernwood-Heath 1 (25)	36	42	8	14	8	0	14
Fernwood-Heath 2 (18)	31	19	23	29	10	0	6
VonHumboldt-Donnelly 1 (12)	17	24	29	0	12	0	35
VonHumboldt-Donnelly 2 (9)	13	38	8	8	0	15	15
VonHumboldt-Donnelly 3 (14)	22	27	18	0	23	9	18
—Conventional—							
Addams-St.James 1 (19)	33	58	9	9	3	3	15
Addams-St.James 2 (19)	33	33	3	3	18	0	39
Wacker-McLaughlin 1 (18)	27	30	7	15	7	4	33
Wacker-McLaughlin 2 (11)	23	48	22	13	0	4	9
Wacker-McLaughlin 3 (10)	16	38	31	6	6	6	13

[1] Students were asked to describe how they would use mathematics outside of class.

[2] Percentage does not add to 100 due to number of unique responses.

[3] Responses included banking and shopping.

[4] Responses included occupations and school subjects.

In summary, the open-ended responses revealed that students most frequently associated number-related ideas with mathematics and identified service and financial occupations as those that required mathematics. Students noted that they used mathematics outside of school when money was involved or when calculation was necessary.

Data from Student Questionnaires

Other data on student attitudes was gathered through the use of the Student Questionnaire (Shafer, 1997a). In one item, students circled the school subject they enjoyed the most: social studies, science, math, reading, writing, art, music, physical education, band, or self-identified subject. Students generally indicated physical education (PE) and mathematics classes more than other school subjects (see Table 1-30[11]).

Table 1-30
Student Preference Ranking of Classes, Grade 7, District 1 in 1997

School-Class (N)	Subject *(%)*									
	SocStudies	**Science**	**Math**	**Reading**	**Writing**	**Art**	**Music**	**PE**	**Band**	**Other**
—MiC—										
Fernwood-Heath 1 (30)	20	8	20	8	4	4	0	16	0	20
Fernwood-Heath 2 (23)	0	5	0	5	0	10	10	35	0	35
VonHumboldt-Donnely 1 (25)	8	4	13	8	0	13	13	8	13	21
VonHumboldt-Donnely 2 (23)	0	19	10	0	0	5	10	38	5	14
VonHumboldt-Donnely 3 (23)	5	5	0	0	5	16	5	42	0	21
—Conventional—										
Addams-St.James 1 (20)	5	5	25	0	5	5	15	5	0	35
Addams-St.James 2 (19)	5	5	25	0	5	5	15	5	0	35
Wacker-McLaughlin 1 (24)	0	5	29	0	10	5	10	24	0	19
Wacker-McLaughlin 2 (16)	8	0	15	8	0	15	8	31	0	15
Wacker-McLaughlin 3 (16)	0	8	15	0	15	0	0	31	15	15

[11] Student questionnaire data for all Year 1 classes in the study is available in Technical Report 18a, b, c (Romberg, Folgert, Shafer, Arauco, & Dremock, 2001).

Students also identified the frequency with which they talked about three items with their classmates, friends, or acquaintances about: (a) mathematical ideas and ways to solve problems, (b) mathematical problems assigned for homework, and (c) ways that mathematics was used outside of school. They circled a response on a scale that included Never, Sometimes, Often, and Very Often. Responses indicated that students sometimes talked with others about mathematical ideas and problem solving strategies and frequently talked with others about homework (see Table 1-31). Results were mixed with respect to talking about the ways mathematics is used outside of school.

Table 1-31

Student Judgment About Frequency of Communication About Mathematics, Grade 7, District 1 in 1997

School-Class *(N)*	**Mathematical Ideas and Problem Strategies**					**Homework Problems**					**Ways Mathematics is Used Outside of School**				
	(*N*)	**Never**	**Some-times**	**Often**	**Very Often**	**(*N*)**	**Never**	**Some-times**	**Often**	**Very Often**	**(*N*)**	**Never**	**Some-times**	**Often**	**Very Often**
— MiC —															
Fernwood-Heath 1 (30)	25	12	56	16	16	25	8	44	44	4	25	40	28	16	16
Fernwood-Heath 2 (23)	19	16	42	26	16	19	26	37	21	16	19	37	26	21	16
VonHumboldt-Donnely 1 (25)	24	21	63	8	8	24	17	38	42	4	24	29	54	8	8
VonHumboldt-Donnely 2 (23)	21	57	38	5	0	21	24	52	19	5	21	67	24	10	0
VonHumboldt-Donnely 3 (23)	19	37	53	11	0	19	5	63	32	0	19	32	42	26	0
—Conventional —															
Addams-St.James 1 (20)	20	30	35	25	10	20	5	35	25	35	20	40	35	10	15
Addams-St.James 2 (19)	19	37	47	11	5	19	16	21	47	16	19	47	42	5	5
Wacker-McLaughlin 1 (24)	21	10	62	19	10	21	14	19	38	29	21	19	43	29	10
Wacker-McLaughlin 2 (16)	13	8	38	23	31	13	0	54	31	15	13	31	54	15	0
Wacker-McLaughlin 3 (16)	13	0	85	8	8	13	0	46	31	23	13	46	23	23	8

Note: Response rates designate class mean percents.

Students also responded to three open-response items in which they listed three things they enjoyed most and three things they enjoyed least about their mathematics class, and identified ways their knowledge of mathematics and the way they learned mathematics helped them in other classes. Overall, students at different grade levels and students studying MiC or conventional curricula responded in similar ways to the open-response items on the Student Questionnaire. Students reported the things they liked and disliked the most about mathematics class (see Tables 1-32 and 1-33). In most classes, students reported that they liked problem solving and miscellaneous class activities and disliked classwork.

Table 1-32

What Students Liked Most About Mathematics Class, Grade 7, District 1 in 1997

School-Class *(N)*	**Number of Responses[1] *(N)***	**Number *(%)*[2]**	**Problem Solving *(%)***	**Classwork *(%)***	**Working With Others *(%)***	**Miscellaneous[3] *(%)***	**Negative Emotional Response[4] *(%)***	**Positive Emotional Response[5] *(%)***
—MiC—								
Fernwood-Heath 1 (30)	60	2	13	3	7	10	3	8
Fernwood-Heath 2 (23)	49	6	14	6	4	20	2	6
VonHumboldt-Donnelly 1 (25)	56	11	20	9	5	27	2	9
VonHumboldt-Donnelly 2 (23)	47	0	17	15	4	26	2	9
VonHumboldt-Donnelly 3 (22)	50	0	24	8	4	16	2	8
—Conventional—								
Addams-St.James 1 (20)	57	14	18	7	11	7	4	5
Addams-St.James 2 (19)	53	28	21	6	6	11	2	6
Wacker-McLaughlin 1 (24)	48	6	15	17	8	13	0	13
Wacker-McLaughlin 2 (16)	35	9	11	0	6	29	0	20
Wacker-McLaughlin 3 (16)	36	0	6	0	8	44	0	17

[1] Students were asked to name three things they liked most about mathematics class.

[2] Percentage does not add to 100 due to number of unique responses.

[3] Responses included "teacher," "computer," and "warm-up activities."

[4] Responses included "hard," "boring," and "restrictive."

[5] Responses included "like it all" and "fun."

Table 1-33

What Students Disliked Most About Mathematics Class, Grade 7, District 1 in 1997

School-Class *(N)*	**Number of Responses[1] *(N)***	**Number *(%)* [2]**	**Classwork *(%)***	**Homework *(%)***	**Tests *(%)***	**Problem Solving *(%)***	**Book *(%)***	**Miscellaneous [3] *(%)***	**Negative Emotional Response[4] *(%)***	**Positive Emotional Response[5] *(%)***
—MiC—										
Fernwood-Heath 1 (30)	55	5	13	7	13	4	7	13	7	2
Fernwood-Heath 2 (23)	42	21	21	10	14	2	2	2	5	0
VonHumboldt-Donnelly 1 (25)	48	8	29	6	2	0	2	25	6	6
VonHumboldt-Donnelly 2 (23)	49	14	33	16	2	2	0	12	6	0
VonHumboldt-Donnelly 3 (22)	44	7	14	9	25	7	7	2	11	7
—Conventional—										
Addams-St.James 1 (20)	62	0	16	27	39	2	2	11	2	0
Addams-St.James 2 (19)	45	2	13	20	40	4	0	2	7	2
Wacker-McLaughlin 1 (24)	50	4	16	16	14	12	4	12	8	0
Wacker-McLaughlin 2 (16)	30	20	7	10	3	10	13	17	3	3
Wacker-McLaughlin 3 (16)	29	10	17	14	21	0	0	0	0	14

[1] Students were asked to name three things they disliked the most about mathematics class.

[2] Percentage does not add to 100 due to number of unique responses.

[3] Responses included "teacher," "computer," and "warm-up activities."

[4] Responses included "hard," "boring," and "restrictive."

[5] Responses included "like it all" and "fun."

When students reported the ways mathematics helped them in other subjects (see Table 1-34), they frequently indicated that mathematics was used in both general applications, such as estimating and calculating, and specific applications, such as measurement and problem solving. It is also notable that several classes indicated that mathematics did not help them in other classes.

Table 1-34

Student Perception of the Usefulness of Mathematics in Other Classes, Grade 7, District 1

School-Class *(N)*	Number of Responses[1] *(N)*	General Applications[2] *(%)*	Specific Applications[3] *(%)*	Organization of Information *(%)*	No Help *(%)*	Miscellaneous *(%)*	Inappropriate Responses[4] *(%)*
—MiC—							
Fernwood-Heath 1 (30)	38	13	18	0	8	3	58
Fernwood-Heath 2 (23)	25	24	12	0	16	8	40
VonHumboldt-Donnelly 1 (25)	32	13	28	3	13	0	44
VonHumboldt-Donnelly 2 (23)	25	8	20	4	24	0	44
VonHumboldt-Donnelly 3 (22)	26	19	0	12	19	8	42
—Conventional—							
Addams-St.James 1 (20)	40	23	50	5	3	3	18
Addams-St.James 2 (19)	32	13	56	3	3	3	22
Wacker-McLaughlin 1 (24)	33	27	30	0	3	3	36
Wacker-McLaughlin 2 (16)	21	33	24	0	10	0	33
Wacker-McLaughlin 3 (16)	18	0	17	22	17	6	39

[1] Students were asked to identify how their knowledge of mathematics and the way they learned mathematics helped them in other classes.

[2] Responses included "estimating" and "calculating."

[3] Responses included "measurement" and "problem solving."

[4] Responses included "not good at math", "need to know something", "it's easier and more fun", "not good ", etc.

Conclusion

The results of the initial administration of the SAI suggest that students felt that they would succeed in mathematics class if they put forth the effort, and they felt confident in their abilities to do mathematics and communicate mathematically. Students were interested in mathematics, and they felt that mathematics was useful in their daily lives. Students were confident they could learn mathematics and solve problems, and they recognized the importance of effort in learning mathematics. Students generally attributed success in mathematics to a combination of effort and ability, and failure to lack of effort. Fifth-grade students were more positive than other students in terms of interest in and excitement about mathematics, which correlates with previous research that students' interest in mathematics declines from elementary school through middle school. Few significant differences between students studying MiC and those studying conventional curricula were apparent. Results on the SAI and Student Questionnaire were very similar across grade levels and districts. Thus, at the beginning of the study, students' attitudes toward mathematics were comparable in nature.

Conclusions

It is important to know some of the characteristics of the students participating in the study as it began. In summary, the responses by students to the questionnaire, standardized tests, test of mathematical reasoning, and attitude survey has provided considerable information about each student. Given the sites of the four school districts and their features we expected some differences across the districts and across classes within districts, and were surprised by others. We expected across district variability in their ethnic characteristics because of the nature of the communities, little variability in age or gender differences across districts, minimal differences in overall standardized test percentiles across districts, etc. We expected within district variability on standardized test percentiles, but were surprised at the magnitude of the differences. We were disappointed in the differences in mean percentiles across classes (particularly at grade 5 in District 1), and disappointed in the large differences in prior test scores between the MiC and conventional classes. We were also disappointed in the lack of meaningful differences between classes on both the *Collis-Romberg* test and the attitude survey.

Two conclusions seem warranted from this background data. First, the unit of analysis for the study is problematic. Clearly, the primary unit of analysis should not be the district, or school. The variability across classes within schools and districts makes it clear that the class (or possibly the teacher) should be the unit of analysis. This issue will be addressed again in later chapters as teacher background, instruction, and so forth are examined in detail. Second, in year 1 of the study the proposed index of prior achievement (PA) should be the prior standardized test percentiles. Given the observed variability across classes within districts on the percentiles, and the high correlation between the percentiles and the unistructural measure on the *Collis-Romberg* test this seems warranted.

CHAPTER 2: INFORMATION ON TEACHER BACKGROUND VARIABLES

Thomas A. Romberg, Mary C. Shafer, Lorene Folgert, Supiya Balakul, Chul Lee, and Joan Kwako

The purpose of this chapter is to summarize the information gathered about the *Teacher Background* variables collected in 1997 on fifth-grade, sixth-grade, and seventh-grade classes at the beginning of the longitudinal/cross-sectional study of the impact of *Mathematics in Context* on student performance, and to add to that information similar data on eighth-grade teachers who joined the project in year 2 and teachers in grades 6 and 7 new to the project in years 2 and 3. The purpose of gathering this information was to describe similarities and differences among the teachers on three types of characteristics prior to instruction (see Figure 2-1). While the primary data collected reflects information as of the first year of the study.

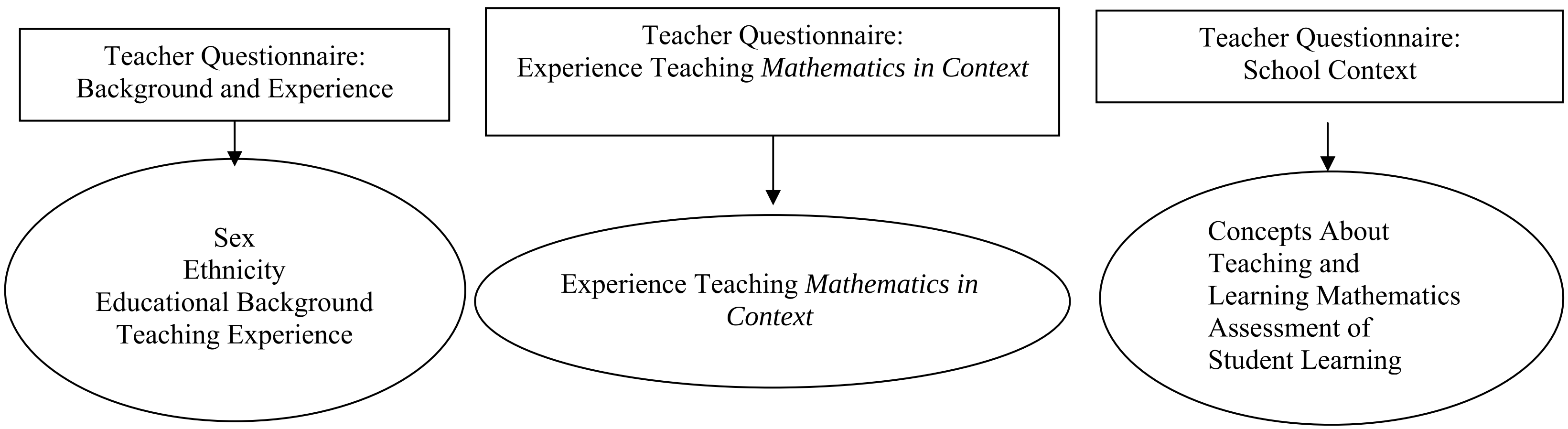


Figure 2-1. Teacher background characteristics in longitudinal/cross-sectional study of the impact of *Mathematics in Context* on student performance and their sources.

Teachers in the Study

During the fall of 1997 19 fifth-grade teachers, 19 sixth-grade teachers[12], and 15 seventh-grade teachers from 17 schools in four districts participated in the study. Over the three years of the study 9 additional sixth-grade teachers, 15 additional seventh-grade teachers, and 20 eighth-grade teachers[13] joined the study. Thus, over the three years of the study a total of 97 teachers participated in the study. Districts are identified by number; school and teacher names are pseudonyms. Also noted are the type of materials used (MiC materials or a conventional text). Detailed information on all of the teachers involved in this study can be found in three Technical Reports (Shafer, Lee, & Folgert, 2003; and Romberg, Shafer, Folgert, Balakul, & Lee, 2002a and 2002b). Also, all of the data collected reflects information as of the first year the teacher was in the study.

General Characteristics

Initially the general background characteristics for teachers at each grade level — gender, ethnicity, educational background, teaching experience, experience teaching mathematics, and experience teaching at the current school — were gathered via the Teacher Questionnaire: Background and Experience (Shafer, Davis, & Wagner, 1997a). The information collected is summarized for the teachers at each of the four grade levels.

<u>Grade 5 Teachers</u>

The summary information for the 19 fifth-grade teachers is presented in Table 2-1. Of the19 teachers there were 18 females and 1male; 14 were White[14], 3 were African American, and 1 was Multiracial; the number of years teaching varied from 4 to 26 years (with 15 having taught for more than 10 years); all had taught at their current school at least one year prior to the study: all but 2 had taught at several grades.

---

[12] Note that in District 1 one teacher replaced another teacher early in year 1.
[13] One teacher in District 4 was a sixth grade teacher in years 1 and 2, and taught eighth grade in year 3.
[14] One teacher in District 3 did not complete the teacher questionnaire.

Table 2-1

Summary Data on Background Characteristics, Fifth-Grade Teachers

Teacher	Sex	Ethnicity	Full-Time Teaching (years)	Part-Time Teaching (years)	Teaching at School (years)	Current Grade Level	Grade Levels Taught	Current Position
District 1								
— *MiC* —								
Banneker-Greene[1]	F	White	26	1	7	5	K,1,2,4 and College	Classroom teacher
Beethoven-Kipling[1]	F	White	5	1	2	5	3,4,5	Classroom teacher
Beethoven-LaSalle[1]	F	White	15	0	8	5	2,3,4,5,6	Classroom teacher, Mentor teacher
Beethoven-Linne[1]	F	White	10	0	8	5	4,5,6,7	Classroom teacher, Mentor teacher, Department chair, Union Rep., Team Leader
Dewey-Hamilton[1]	F	White	18	5	14	5	4,5,6	Classroom teacher
Dewey-Mitchell[1]	F	African American	19	1	4	5	K,1,3,4,5	Classroom teacher
— *Conventional* —								
Dewey-Kershaw[1]	F	White	10	1	6	5	5	Classroom teacher
River Forest-Fulton[1]	M	White	23	0	20	5	5,6	Mathematics specialist for the school
District 2								
— *MiC* —								
Armstrong-Murphy[1]	F	White	8	15	8	5	Computers,2,4	Classroom teacher
Armstrong-Nash[1]	F	Black	15	10	12	5	3,4,5	Classroom teacher
Ogden-Fiske[1]	F	White	11	1	3	5	5,6	Classroom teacher
Ogden-Piccolo[1]	F	White	11	0	3	5	4,5,6	Classroom teacher
— *Conventional* —								
Von Steuben-Gant[1]	F	African American	12	0	11	5	3,4,5	Classroom teacher, Lead teacher, Department chair, USI Teacher Consultant
District 3								
— *MiC* —								
Taft-Allen[1,*]	F	White						
Taft-Cameron[1]	F	White	23	3	1	5	1,2,3,4,5,6	Classroom teacher
Taft-Cooper[1]	F	White	11	0	10	5	K,1,5	Classroom teacher
Taft-DeLaCruz[1]	F	White	7	N/A	7	5	1,5	Classroom teacher
Taft-Dodge[1]	F	Multiracial	20	2	9	5	K,2,3,4,5,6	Mentor teacher
Taft-Edgebrook[1]	F	White	4	N/A	4	5	5	Classroom teacher

[*] Allen did not submit a teacher questionnaire

[1] Participated in study in 1997-1998

In District 1 most of the teachers had completed a bachelor's degree in elementary education; one teacher had completed a bachelor's degree in psychology. The teachers varied in their undergraduate mathematics preparation from no courses to 6–7 courses. Six of the eight teachers had completed a master's degree: three teachers had studied education; two teachers had studied school leadership or administration; and one teacher had studied family studies. Five of these teachers had taken at least one graduate-level course in mathematics. One teacher had completed doctoral work in family studies.

Among the fifth-grade teachers in District 2, three did not take or report any mathematics credits in their bachelor degree. One studied administration in elementary education and holds certification in administration. One studied reading for her master's degree. Another studied music, took one mathematics education course, and later studied computer applications for her master's degree. The last teacher completed a master's degree in elementary education.

The educational backgrounds of the fifth-grade teachers in District 3 differed dramatically. They studied Sociology, Liberal Studies, Environmental Studies, and Behavioral Science. Credits in mathematics also differed from one statistics course to accounting, and credits from outside education.

Grade 6 Teachers

In 1997 19 sixth grade teachers participated in the study. Of those teachers 11 also participated in the study the second year, and 9 new teachers were added. Summary information for all 28 teachers is presented in Table 2-2. Twenty-two of the teachers were female and 6 were male; 21 were White, 6 were African American, and 2 were Asian American; the number of years teaching varied (the range is from 0 to 24 years with 10 having taught for more than 10 years); all but 4 had taught at their current school at least one year prior to the study.

Table 2-2

Summary Data on Background Characteristics, Sixth-Grade Teachers

District / School-Teacher	Sex	Ethnicity	Full-Time Teaching (years)	Part-Time Teaching (years)	Teaching at School (years)	Current Grade Level	Grade Levels Taught	Current Position
District 1								
— *MiC* —								
Addams-Gollen[1]	F	White	16	2	1	6	2,3,4,pre-school	Mathematics Specialist
Fernwood-Lee[2]	F	White	24	0	11	6	1,2,3,5,6	Lead Teacher
Fernwood-Weatherspoon[1,2]	F	White	0	3	0	6	Subst.teacher-1, 2, 3, 4, 5, 6, 7, 8	Classroom teacher
Von Humboldt-Brown[1,2]	M	White	12	4 summers	10	6	4,5,6,7	Lead Teacher
Von Humboldt-Harvey[1]	M	White	2	1	1	6	8,9	Classroom teacher
Von Humboldt-Parsons[1]	F	Asian American	1	1/4	0	6	4,5,6	Classroom teacher
Wacker-Lovell[1]	F	White	23	0	11	6	3,4,5,6	Classroom teacher, Lead Teacher (Science), Department chair (Science)
— *Conventional* —								
Addams-Tallackson[2]	F	White	4	1	3	6,7,8	4,5,6,7,8	Regular and Special Ed. Teacher, Educational Diagnostician
Fernwood-Harrison[1]	F	White	2	0	0	6	6,7	Classroom teacher
Wacker-Krittendon[2]	F	White	23	0	7	6	K,1,2,3,4,5,6,7,8	Classroom teacher
District 2								
— *MiC* —								
Guggenheim-Broughton[1,2,(3)*]	F	African American	12	N/A	12	6,7,8	6,7,8,9	Classroom teacher, Lead teacher
Guggenheim-Dillard[(1)**,2]	M	White	4	0	3	6	6,7,8,9,10,11,12	Classroom teacher
Guggenheim-Redling[1]	F	White	14	0	2	6	6,7,8	Classroom teacher
Hirsch Metro-Davenport[2]	F	African American	4.5	0	4	6	6,7,8,10,11	Classroom teacher
Hirsch Metro-Holland[2]	M	White	5	2	3	6	6,7,8	Classroom teacher
Weir-Ferguson[1]	F	White	2	0	1	6	2	Classroom teacher
Weir-Kellner[1,***]	F	Asian American						
— *Conventional* —								
Newberry-Renlund[1,2]	F	African American	2	1	1	6,8	6,8	Classroom teacher
Newberry-Rhaney[2]	M	African American	1	0	1	6	7	Classroom teacher
Von Steuben-Friedman[1]	F	White	6	18	0	6,7	5,6,7,8,9,10,11	Classroom teacher

[*] Broughton participated in study in 1997-1998 and 1998-1999 teaching Grade 6 *MiC* curriculum and in 1999-2000 teaching Grade 7 *MiC* curriculum.

[**] Dillard participated in study in 1997-1998 teaching Grade 6 *MiC* curriculum, in 1998-1999 teaching Grade 7 *MiC* curriculum, and in 1999-2000 teaching Grade 8 *MiC* curriculum.

[***] Kellner did not complete teacher questionnaire.

[1] Participated in study in 1998-1999.

[2] Participated in study in 1997-1998.

[3] Participated in study in 1999-2000.

Table 2-2 *continued*

District / School-Teacher	Sex	Ethnicity	Full-Time Teaching (years)	Part-Time Teaching (years)	Teaching at School (years)	Current Grade Level	Grade Levels Taught	Current Position
District 3								
— *MiC* —								
Calhoun North-Bragg[2]	F	White	7	0	1	6	1,6	Classroom teacher
Calhoun North-Schlueter[1,2]	F	White	1	N/A	1	6	stud.teacher-1,4	Classroom teacher
Calhoun North-Solomon[1,2]	F	White	9	1	8	6	6	Lead Teacher
Calhoun North-Tierney[1,2]	M	White	18	5	7	6	3,4,5,6,7,8 and College	Classroom teacher
Calhoun North-Vetter[1,2]	F	White	14	N/A	10	6,7	3,4,5,6,7	Resource Teacher
District 4								
— *MiC* —								
Kelvyn Park-Becker[1]	F	White	0	2	0	6	2,3	Classroom teacher
Kelvyn Park-Downer[1,2,(3)*]	F	African American	10	1	8	6	6,7,8	Classroom teacher
Kelvyn Park-Vega[1,2]	F	White	10	3	5	6	6,7,8,9,10,11	Classroom teacher

[*] Downer participated in study in 1997-1998 and in 1998-1999 teaching Grade 6 students *MiC* curriculum and in 1999-2000 teaching Grade 8 *MiC* curriculum.
[1] Participated in study in 1998-1999.
[2] Participated in study in 1997-1998.
[3] Participated in study in 1999-2000.

In 1997 among the 6 sixth-grade teachers of District 1, most teachers completed a bachelor degree in elementary education; with one exception studying History, but she completed a master's degree in elementary education. The teachers who majored in elementary education generally took 3 to 6 mathematics courses. Three of the four new teachers to the study in 1998 in District 1 were also elementary education majors with few mathematics courses. The remaining new teacher did not complete the questionnaire.

Two of the six sixth-grade teachers in District 2 in 1997 studied mathematics or mathematics education as a major. Other teachers studied a business-related field, health science, or engineering. Bachelor credits in mathematics differed according to their major ranging from 0 to 18 courses. Three of the four new teachers in 1998 majored in elementary education, special education, and mathematics education with 3 to 15 mathematics courses. The remaining new teacher did not complete the questionnaire.

The five sixth-grade teachers in District 3 in 1997 had dramatically different educational backgrounds, none of which included a bachelor's degree in education. In addition, undergraduate credits in mathematics varied from one to four. One teacher completed both bachelor and masters degrees in psychology and taught at the community college level. There were no new teachers in this district in the study in 1998.

In 1997 the two sixth-grade teachers in District 4 reported having majors in mathematics. Both studied masters' courses related to mathematics or mathematics education as their major. One is currently working toward a doctoral degree in mathematics education. The one new teacher in District 4 in 1998 also majored in mathematics and had taken five courses toward a master's degree in mathematics.

Grade 7 Teachers

In 1997 17seventh grade teachers participated in the study. Of those teachers 7 also participated in the study the second year and 9 new teachers were added. Then in the third year 5 teachers had participated all three years of the study[15], 3 had participated only in years two and three, and 5 were new to the study. Summary information for all 30 teachers is presented in Table 2-3. Twenty-one of the teachers were female and 9 were male; 19 were White, 6 were African American, 3 were Hispanic, 1 was Asian American, and 1 Multiracial; the number of years teaching varied from 1/2 year to 38 years (with 12 having taught for more than 10 years)[16]; all but 3 teachers had taught at their current school at least one year prior to the study: all but one had taught at several grades.

[15] One teacher in District 2 taught grade 6 in years 1 and 2 and grade 7 in year 3.
[16] One teacher in District 4 did not submit a teacher questionnaire.

Table 2-3

Summary Data on Background Characteristics, Seventh-Grade Teachers

District / School-Teacher	Sex	Ethnicity	Full-Time Teaching (years)	Part-Time Teaching (years)	Teaching at School (years)	Current Grade Level	Grade Levels Taught	Current Position
District 1								
— *MiC* —								
Addams-St.James[(1,2)*,3]	M	White	3	3	2	7	6,9,10,11	Classroom teacher, Department chair
Fernwood-Heath[1,2]	F	White	4	0	3	7	7,10,11,12	Classroom teacher
Von Humboldt-Bartlett[2]	M	White	2	0	0	7	4,5,6	Classroom teacher
Von Humboldt-Botkin[3]	F	White	4	4	1	7	0	Classroom teacher
Von Humboldt-Donnely[1]	M	White	13	7	0	7	5,6,7,8,9,10,11,12 and College	Classroom teacher
Von Humboldt-Muldoon[2,3]	F	Multi-cultural	38	some summers	3	7	Head Start (4yr-olds) to adult	Classroom teacher
Wacker-Burton[2]	F	White	1	0	0	7	7	Classroom teacher
— *Conventional* —								
Addams-St.James[1,2,(3)*]	M	White	3	3	2	7	6,9,10,11	Classroom teacher, Department chair
Fernwood-Hodge[2,3]	M	White	2	1/2	1	7	7	Classroom teacher
Von Humboldt-McLaughlin[1]	F	White	4+	0	4	7	7,8	Classroom teacher
Wacker-Rubin[2]	F	White	1/2	0	0	7	3 spec.ed,6,7	Classroom teacher
District 2								
— *MiC* —								
Guggenheim-Keeton[1,(2)**]	F	African American	18	0	13	6	6,7,8,9	Department chair
Guggenheim-Teague[1,(2)*]	F	White	24	0	10	7	3,6,7,8	Classroom teacher, Team Leader
Hirsch Metro-Draski[1]	F	African American	4	0	34	7	6,7,8	Classroom teacher
Hirsch Metro-McFadden[1]	F	White	18	0	10	7	4,6,7,8,9,10,11,12	Department chair
— *Conventional* —								
Newberry-Cunningham[1,2,***]	F	African American	11	0	10	7,8	K,6,7,8,9,10,11,12	Lead Teacher
Newberry-Stark[1,(2)****]	F	White	6	10	1	7	6,7,8,College and Adults	Classroom teacher

* St.James participated in study teaching Grade 7 conventional curriculum in 1997-1998 and 1998-1999 and teaching Grade 7 *MiC* curriculum in 1999-2000.

** Keeton and Teague participated in study teaching Grade 7 *MiC* curriculum in 1997-1998 and teaching Grade 8 *MiC* curriculum in 1998-1999.

*** Cunningham taught at Grades 7 and 8 in 1998-1999.

**** Stark taught at Grade 8 in 1998-1999.

1 Participated in study in 1997-1998.

2 Participated in study in 1998-1999.

3 Participated in study in 1999-2000.

Table 2-3 *continued*

Teacher	Sex	Ethnicity	Full-Time Teaching (years)	Part-Time Teaching (years)	Teaching at School (years)	Current Grade Level	Grade Levels Taught	Current Position
District 3								
— MiC —								
Calhoun North-Perry[1, 2, 3]	F	White	9	0	9	7	7,8,9 and Adult	Classroom teacher
Calhoun North-Schroeder[1, 2, 3*]	F	White	25	0	19	7,8	2,3,5,6	Special Education Teacher
District 4								
Teacher	**Sex**	**Ethnicity**	**Full-Time Teaching (years)**	**Part-Time Teaching (years)**	**Teaching at School (years)**	**Current Grade Level**	**Grade Levels Taught**	**Current Position**
— MiC —								
Kelvyn Park -Finn[1, 2]	F	Hispanic	9	0	6	7	6,7,8	Classroom teacher
Kelvyn Park-Kane[2, 3]	F	Hispanic	4	0	3	7	6,8	Classroom Teacher
Kelvyn Park-Lux**,[3]	F							
Kelvyn Park-Woodward[1, 2, 3]	M	African American	1	0	1	7	7,8	Classroom teacher
Kelvyn Park MS-Yackle[1]	M	White	27	1 or 2	10	7		Classroom teacher

[*] Schroeder participated in study in 1997-1998 and in 1998-1999 teaching Grade 7 students *MiC* curriculum and in 1999-2000 teaching Grades 7 and 8 *MiC students.*

[**] Lux did not complete a teacher questionnaire

[1] Participated in study in 1997-1998

[2] Participated in study in 1998-1999

[3] Participated in study in 1999-2000

In 1997 the four seventh-grade teachers in District 1 had majors or minors in mathematics, each listing 9 to 10 courses in mathematics. Among these teachers one was studying math education at the master's level, and another was enrolled in a master's program in Curriculum and Instruction. Four of the five new teachers in this District in 1998 had elementary education majors with 1 to 10 courses in mathematics. The final new teacher majored in psychology and had a master's degree in elementary education.

The seventh-grade teachers in District 2 varied in their majors and the mathematics credits they studied. Three business-related majors and three education majors were reported. The number of mathematics courses taken varied from 0 to 4 courses.

Grade 8 Teachers

In 1998, starting in the second year of the study, 14 eighth grade teachers participated in the study. Of those teachers 8 also participated in the study the third year, and 6 new teachers were added. Summary information for all 20 teachers is presented in Table 2-4. 16 of the teachers there were female and 4 were male; 13 were White, 5 were African American, and 2 Multiracial; the number of years teaching varied (the ranging from 5 to 29 years with 13 having taught for more than 10 years); all but one had taught at their current school at least one year prior to the study.

Table 2-4
Summary Data on Background Characteristics, Eighth-Grade Teachers

Teacher	Sex	Ethnicity	Full-Time Teaching (years)	Part-Time Teaching (years)	Teaching at School (years)	Current Grade Level	Grade Levels Taught	Current Position
District 1								
— MiC —								
Fernwood-Dunn[*,1]	F	African American						
Fernwood-Reichers[1, 2]	F	White	15	0	15	8	8 math, 6, 7, 8 music	Classroom Teacher
Von Humboldt-Waters[1, 2]	F	White	8	0	4	8	7, 8, 9, 10, 11, 12	Classroom Teacher
— Conventional —								
Addams-Wolfe[*, 1, 2]	F	White						
Fernwood-Pimm[1]	F	White	11.5	0	2	8	2, 3,4,6,8	Classroom Teacher
Wacker-DiMatteo[2]	F	White	11	2	0	8	K, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	Classroom Teacher

[*] Dunn and Wolfe did not comlete teacher questionnaire

[1] Participated in study in 1999-2000

[2] Participated in study in 1998-1999

Teacher	Sex	Ethnicity	Full-Time Teaching (years)	Part-Time Teaching (years)	Teaching at School (years)	Current Grade Level	Grade Levels Taught	Current Position
District 2								
— *MiC* —								
Guggenheim-Carlson[1,(2)**]	F	White	5		2	8	6, 7, 8, 9, 10, 11	Classroom Teacher
Guggenheim-Dillard[1,(2)**]	M	White	6		5	8	6, 7, 8, 9, 10, 11, 12	Classroom Teacher
Weir-Gallardo[1,(2)**]	M	African American	29	0	14	7, 8	K, 1, 2, 3, 4, 5, 6, 7, 8	Department Chair
Weir-Shepard[*,1]	1	Other (Jamacian/ Indian)						
Guggenheim-Keeton[2,(3)***]	F	African American	19	0	14	8	6, 7, 8, 9	Department Chair
Guggenheim-Teague[2,(3)***]	F	White	25	0	11	8	3, 6, 7, 8	Classroom Teacher, Team Leader
— *Conventional* —								
Newberry-	F	African American	12	0	11	7, 8	K, 6, 7, 8, 9, 10, 11, 12	Lead Teacher
Newberry-Stark[2]	F	White	7	10	2	8	6, 7, 8and College (freshman and Non-credit Adults)	Classroom Teacher
District 3								
— *MiC* —								
Calhoun North-Wells[1, 2]	F	Multi-cultural	23	2	21	8	4, 5, 6, 7, 8, 9	Classroom Teacher
Calhoun North-Schroeder[1*****]	F	White	27		21	7, 8	2, 3, 5, 6	Special Education Teacher
District 4								
— *MiC* —								
Kelvyn Park-Catalano[2]	F	White	11	0	11	8, 9	6, 7, 8, 9	Classroom Teacher
Kelvyn Park-Downer[1,(2,3)**]	F	African American	12	1	10	6	6, 7, 8	Classroom Teacher
Kelvyn Park-Novak[1, 2]	M	White	10	0	9	8	6, 7, 8	Lead Teacher
Kelvyn Park-Woods[1, 2]	M	White	15 and 1/2	0	4	8	7, 8	Classroom Teacher

[*] Shepard did not comlete teacher questionnaire

[**] Carlson, Dillard, and Gallardo taught at Grade 7 in 1998-1999.

[***] Keeton and Teague participated in study teaching Grade 7 *MiC* curriculum in 1997-1998 and teaching Grade 8 *MiC* curriculum in 1998-1999.

[****] Cunningham taught at Grades 7 and 8 in 1998-1999.

[*****] Schroeder participated in study in 1997-1998 and in 1998-1999 teaching Grade 7 students *MiC* curriculum and in 1999-2000 teaching Grades 7 and 8 *MiC students.*

[******] Downer participated in study in 1997-1998 and in 1998-1999 teaching Grade 6 students *MiC* curriculum and in 1999-2000 teaching Grade 8 *MiC* curriculum.

[1] Participated in study in 1999-2000

[2] Participated in study in 1998-1999

[3] Participated in study in 1997-1998

Table 2-4 *continued*

Among the eight eighth-grade teachers in District 1 one majored in mathematics education, one in music, two in education, the others did not complete the questionnaire. None of the teachers indicated they had taken any mathematics courses. In District 2 of eight teachers one majored in mathematics education, one in psychology, two in education, three in business, and one did not complete the questionnaire. Also, only two teachers indicated that they had taken mathematics courses. In District 3 one of the two teachers majored in education and the other in social science, and both indicated they had taken several mathematics courses. Then finally in District 4 of the four teachers two had majored in mathematics, one in speech, and one in marketing. All four had taken several mathematics courses.

In summary, for the 97 teachers who participated in the study, 77 were female and 20 male; 68 were white, 19 African-American, 3 Hispanic, 3 Asian-American, and 5 multicultural; and 50 of the 95 who submitted surveys had taught more than 10 years. Also, the middle school teachers who participated in this study varied in their professional training. In fact, with a few exceptions this group of teachers had minimal mathematics backgrounds. They had taken few mathematics courses related to the mathematical content that is included in the MiC materials.

Experience Teaching MiC

Information about prior experience teaching *Mathematics in Context* units was gathered via a second Teacher Questionnaire: Experience Teaching *Mathematics in Context* (Shafer, 1997b). Again, the information collected is summarized for the teachers at each of the four grade levels.

Grade 5 Teachers

In District 1 two of the five MiC teachers had each taught one MiC unit in the previous year. In District 2 among the 4 teachers who used MiC, two taught 2 or more units in previous years. While in District 3 all of the fifth-grade had one-year experience teaching 2 to 4 MiC units in the previous year.

Grade 6 Teachers

Of the sixth-grade teachers in District 1, one had experience teaching MiC, though she had not taught it in the previous year, and the other two had no previous experience teaching MiC. All of the sixth-grade MiC teachers in District 2 had taught MiC during at least one semester, and three teachers from Hirsch Metro Middle School had two years experience teaching MiC. The number of MiC units taught in previous years varied from one to 5 units.

All sixth-grade teachers in District 3 had used MiC. One teacher had two years experience teaching MiC; and the other teachers had one semester or less than one semester experience teaching MiC. In District 4 two of the three teachers had taught MiC the previous year, the third had no prior experience with the program.

Grade 7 teachers

In District 1 of the seven MiC teachers five had taught MiC for a semester or more prior to the study, the other two had no experience. Each of the seventh-grade MiC teachers in District 2 taught at least 2-4 MiC units in the year prior to the study and three teachers had two years or more experience teaching MiC. The specific units taught were different according to schools. In District 3 both teachers had two years experience teaching MiC and had used 2 to 4 units in the previous year. In District 4 although three seventh-grade teachers were teaching MiC, none had prior experience with the materials.

Grade-8 teachers

Two of the three MiC teachers in District 1 had taught MiC units for a semester or more in prior years. In District 2 five of the six MiC teachers had taught MiC for one or two years. The one eighth-grade teacher in District 3 had taught MiC for more than two years. Then in District 4 all five MiC teachers had taught the program in prior years. Again in all instances a variety of units had been used.

In summary, almost all of the MiC teachers in this study had taught at least one unit prior to the study, a few had taught 2 to 4 units, but none had taught a full year of the program. Thus, all teachers had some familiarity with the MiC program prior to the study.

Teacher Beliefs About the Teaching and Learning of Mathematics

Information about each teacher's conceptions about mathematics teaching and learning and their assessment of student learning were gathered via a third Teacher Questionnaire: School Context (Shafer, Davis, & Wagner, 1997b). In this questionnaire teachers were asked to respond using a five-point Likert scale to twenty-two questions about their beliefs about the teaching and learning of mathematics. The interspersed questions were on the Characterization of Mathematics, Student Learning, and Pedagogy. Initially as the responses to these questions were examined there was considerable variability in responses, but the variability did not appear to be a function of grade level, the district, or the curriculum materials. Thus, for the eighty-two teachers we had complete information on these questions we used cluster analysis on the teachers' responses to the questions on each of the three categories of beliefs.

Characterization of Mathematics.

The following four questions were about characteristics of mathematics. The first two were on a static conception of the subject, and the later two were on a dynamic conception of the discipline.

1. Mathematics is a collection of concepts and skills used to obtain answers to problems.
2. Mathematics is facts, skills, rules, and concepts learned in some sequence and applied in work and future study.

3. Mathematics is thinking in a logical, inquisitive manner and is used to develop understanding.
4. Mathematics is an interconnected logical system that is dynamic and changes as new problem-solving situations arise.

The cluster analysis yielded three groups of teachers. The number of teachers in each group, the group's average rating on each question, and the distribution of grade-level, district and curricula used for the teachers is shown in Table 2-5. The twenty-six Cluster A teachers

Table 2-5

Results of Cluster Analysis on Characteristics of Mathematics

Cluster	*(N)*	Average				Grade				District				Curriculum	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**MiC**	**Conventional**
A	26	4.46	4.73	4.35	4.69	6	6	9	5	8	9	4	5	20	6
B	26	4.31	4.08	3.81	3.92	7	6	9	4	11	11	1	3	21	5
C	30	3.50	4.43	2.17	4.47	7	10	7	6	13	7	8	2	24	6

"strongly agreed" or "agreed" to all four questions. Thus, they made no distinction between the static or dynamic features of the discipline. The twenty-six Cluster B teachers had the same pattern of responses but centered slightly lower agreement than Cluster A teachers. While the thirty Cluster C teachers differed significantly from the other groups on the first and third questions. They were ambivalent about mathematics as a static collection of concepts and skills, but disagreed that mathematics is a dynamic system involving logical thinking. The group's ambivalence is clear in that they agreed with one static question and one dynamic question, and not with the other in each set.

In summary, upon reflection it is clear that these four questions either failed to capture these teachers' beliefs about different notions commonly held about the discipline of mathematics.

<u>Student Learning.</u>

To determine the teachers' views about student learning they were asked to respond using the Likert scale to the following six questions:

1. Students learn best when they study mathematics in the context of everyday situations.
2. Students need to master basic computation facts and skills before they can engage effectively in studying more mathematics.
3. Students must learn basic skills before they can be expected to analyze, compare, and generalize.
4. Students learn mathematics best in classes where they are able to work in small groups.

5. If students use calculators, they won't learn the mathematics they need to know.
6. Students should write about how they solve mathematical problems.

The cluster analysis of the teachers' responses again yielded three groups of teachers. The number of teachers in each group, the group's average rating on each question, and the distribution of grade-level, district and curricula used for the teachers is shown in Table 2-6.

Table 2-6
Results of Cluster Analysis on Student Learning

Cluster	*(N)*	Average						Grade				District				Curriculum	
		1	2	3	4	5	6	5	6	7	8	1	2	3	4	MiC	Conventional
D	29	4.59	1.83	4.14	1.48	4.45	1.83	8	7	9	5	10	7	9	3	21	8
E	19	4.32	3.84	4.00	2.00	4.42	2.11	3	9	6	1	8	8	1	2	17	2
F	33	4.24	4.33	3.88	2.39	4.24	4.21	9	4	11	9	15	10	3	5	26	7

Over the three groups all teachers agreed with situating mathematics in every day situations (question 1), that basic skills should be learned before students can generalize (question 3), that if students use calculators they won't learn (question 5), and all disagreed that students' learn best in small groups (question 4). However, the twenty-nine Cluster D teachers disagreed with question 2 (mastery of facts should precede further study), and question 6 (students should write about how they solve problems). The nineteen Cluster E teachers had the same pattern of responses as the Cluster D teachers except for their agreement on question 2 (mastery of facts should precede further study). While the thirty-three Cluster F teachers differed significantly from the other groups because of their strong agreement on both question 2 (mastery of facts should precede further study), and question 6 (students should write about how they solve problems).

In summary, the patterns of responses by all three groups of teachers reflect the ambiguity in the field about student learning. To be supportive of studying mathematics from the context of everyday situations, be negative about working in groups, and ambivalent about writing about solutions reflect the lack of a firm commitment to a consistent notion of how learning takes place.

<u>Pedagogy.</u>

For the teachers' views about pedagogy teachers were asked to respond using the Likert scale to the following twelve questions:

1. It is more important to cover fewer topics in greater depth than it is to cover the text.

2. More algebra, geometry, probability and statistics should be introduced in the elementary and middle school curriculum.
3. Instruction should include step-by-step directions.
4. Teaching a mathematical concept should begin with a concrete example or model.
5. In teaching mathematics, my primary goal is to help students master basic concepts and procedures.
6. Teachers should plan instruction based upon their knowledge of their students' understanding.
7. More emphasis should be given to simple mental computation, estimation, and less emphasis to practicing lengthy pencil-and-paper calculation.
8. Teachers should encourage children to find their own strategies to solve problems even if the strategies are inefficient.
9. Instruction should include many open-ended tasks.
10. Students should learn mathematics through regularly discussing their ideas with other students.
11. Mathematical problem solving should be a central feature of the elementary and middle school curriculum.
12. In my teaching I try to make connections among mathematical topics and between mathematics and other disciplines.

The cluster analysis of the teachers' responses to these questions also yielded three groups of teachers. The number of teachers in each group, the group's average rating on each question, and the distribution of grade-level, district and curricula used for the teachers is shown in Table 2-7.

Cluster	***(N)***	**Average**												**Grade**				**District**				**Curriculum**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**4**	**MiC**	**Conventional**
G	27	3.41	3.48	2.74	2.11	3.59	4.19	4.15	4.26	3.89	4.00	4.11	4.37	4	7	12	4	12	10	3	2	22	5
H	33	4.70	4.49	3.33	3.21	4.46	4.46	4.33	4.46	4.36	4.55	4.82	4.64	12	9	6	6	11	9	8	5	26	7
I	22	3.91	4.18	3.41	4.14	4.14	3.18	3.59	3.68	3.23	3.77	3.82	4.09	4	5	8	5	10	7	2	3	17	5

Table 2-7
Results of Cluster Analysis on Pedagogy

Overall the three groups were neutral or positive on 34 of the 36 responses. Only Group G was negative on two questions; question 2 about the inclusion of more algebra, geometry, probability, and statistics in the curriculum; and question 4 teaching a concept should begin with a concrete example. Group H was positive on 10 of the 12 questions and neutral on only two. They differed significantly from Group G on question 1 on favoring depth over coverage, question 2 strongly favoring more diversity of content, and question 4 being neutral on beginning with a concrete example. Group J on the other hand was neutral on 8 of the questions and only positive on 4 questions. However, in contrast to both other groups, who were negative and neutral on question 4 about using a concrete example to introduce a concept, this group was positive. Also, where both Groups G and H were positive about planning in terms of student understanding (question 6) and focusing on mental calculation (question 7), Group J was neutral on both.

In summary, the pattern of responses has little overall variation. Only one group differed with two negative responses with respect to broader content and introducing concepts via concrete examples. This is surprising since the majority of this group were MiC teachers and these are both important features of MiC.

Conclusions

This collection of teachers is probably typical of large school districts in that most are female, most are white, most have taught 10 or more years, and most have minimal mathematical background. In fact it is too bad we were unable to collect data on the teachers' knowledge of mathematics. No district was willing to have us test teachers in addition to their students. However, the teachers had no consistent beliefs about the discipline of mathematics, ambiguity about student learning, and in general positive about reform pedagogy.

References

Beaton, A. E., Mullis, I. V. s., Martin, M. O., Gonzalez, E. J., Kelly, D. L., & Smith, T. A. (1996). *Mathematics achievement in the middle school years: IEA's third international mathematics and science study (TIMSS)*. Chestnut Hill, MA: International Association for the Evaluation of Educational Achievement.

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy (structure of observed learning outcomes).* New York: Academic Press.

Brown, C., Carpenter, T., Kouba, V., Lindquist, M., Silver, E., & Swafford, J. (1988). Secondary school results for the Fourth NAEP mathematics assessment: Algebra, geometry, mathematical methods, and attitudes. *The Mathematics Teacher*, *81*(5), 337–347, 397.

Case, R. (1979). The underlying mechanisms of intellectual development. In J. Biggs & J. Kirby (Eds.). *Instructional processes and individual differences in learning.* New York: Academic Press.

Clarke, Wallbridge, and Fraser, S. (1992) *The consequences of a problem-based mathematics curriculum.* Unpublished manuscript.

Cobb, P. (1986). Context, goals, beliefs, and learning mathematics. *For the Learning of Mathematics, 16,* 2-9.

Collins, W., et al. (1998).*Mathematics: Applications and Connections*. Lake Forest, IL: Glencoe.

Collis, K. F., & Biggs, J. B. (1979). *Classroom examples of cognitive development phenomena:The SOLO taxonomy*. Report prepared at the conclusion of an Educational Research and Development Committee funded project, University of Tasmania.

Collis, K. F., & Romberg, T. A. (1992). *Collis-Romberg mathematical problem solving profiles.* Melbourne, Australia: Australian Council for Educational Research.

Confrey, J. (1990). What constructivism implies for teaching. In R. B. Davis, C. A. Maher, & N. Noddings. *Constructivist vies of the teaching and learning of mathematics.* Reston, VA: NCTM.

Crosswhite, F. (1972). *Correlates of attitudes toward mathematics.* (National Longitudinal Study of Mathematical Abilities Report No. 20). Palo Alto, CA: Stanford University Press.

CTB/McGraw-Hill (1992). (5th Ed.). *California Achievement Test.* Monterey, CA: Author.

CTB/McGraw-Hill (1997). *TerraNova.* Monterey, CA: Author.

Cureton, E. F. (1965). Reliability and validity: Basic assumptions and experimental designs. *Educational and Psychological Measurement, 25,* 326-346.

Dossey, J., Mullis, I., Gorman, S., & Latham, A. (1994). *How school mathematics functions: Perspectives from the NAEP 1990 and 1992 assessments* (Report No. 23-FR-02). Washington, DC: Office of Educational Research and Improvement.

Fennema, E., & Sherman, J. (1976a). *Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males.* Madison, WI: Wisconsin Center for Education Research, University of Wisconsin–Madison.

Fennema, E., & Sherman, J. (1976b). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education*, *7*(5), 324-326.

Fennema, E., & Sherman, J. (1986). Fennema–Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education*, *7*(5), 324–326.

Fisher, K. W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review, 86* (6), 477-531.

Harcourt Brace Educational Measurement. (1997). *Stanford mathematics achievement test (SAT), (9th ed.)* San Antonio, TX: Harcourt Brace.

Hart, L. E. & Walker, J. (1993). The role of affect in teaching and learning mathematics. In D. Owens (Ed.), *Research ideas for the classroom: Middle grades mathematics* (pp. 22–38). New York: Macmillan.

Kloosterman, P., & Cougan, M. C. (1994). Students' beliefs about learning school mathematics. *The Elementary School Journal 94*(4), 375-388.

Kloosterman, P., Raymond, A. M., & Emenaker, C. (1996). Students' beliefs about mathematics: A three-year study. *The Elementary School Journal 97*(1), 39–56.

Kloosterman, P., & Stage, F. (1992). Measuring beliefs about mathematical problem solving. *School Science and Mathematics*, *92*(3), 109–115.

Langer, J. (1969). *Theories of development.* New York: Holt, Rinehart, and Winston.

Leder, G. C. (1987). Attitudes toward Mathematics. In T. Romberg & D. Stewart (Eds.), *The monitoring of school mathematics: Background papers, Vol. 2*. Madison, WI: Wisconsin Center for Education Research, University of Wisconsin–Madison.

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education (28)*, 26–47.

Ma, X., & Xu, J. (2004). Determining the causal ordering between attitude toward mathematics and achievement in mathematics. *American Journal of Education (100)*, 256–280.

Marton, F. (1981). Phenomonography – describing conception of the world around us. *Instructional Science, 10*, 177-200.

McLeod, D. (1988). Research on learning and instruction in mathematics: The role of affect. In E. Fennema, T. Carpenter, & S. Lamon (Eds.), *Integrating research on teaching and learning mathematics* (pp. 60–89). Madison, WI: Wisconsin Center for Education Research.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning*. NY: Macmillan.

Middleton, J. A., & Spanias, P. A. (1999). Motivation for Achievement in Mathematics: Findings, Generalizations, and Criticisms of the Research. *Journal for Research in Mathematics Education, 30*(1), 65–88.

National Center for Research in Mathematical Sciences Education & Freudenthal Institute. (Eds.). (1997–1998). *Mathematics in context.* Chicago: Encyclopaedia Britannica.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.

Reyes, L. (1984). Affective variables and mathematics education. *Elementary School Journal*, *84*(5), 558–581.

Romberg, T. A., & Folgert, L. (2005) *Collis-Romberg Mathematical Problem Solving Profile Data.* (*Mathematics in Context* Longitudinal/ Cross-Sectional Study Tech. Rep. No. 50). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Romberg, T. A., Folgert, L., Shafer, M. C., Arauco, T. & Dremock, F. (2001) *Student background data for 1997–1998 (Grades 5, 6, & 7).* (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 18a, b, c). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Romberg, T. A., Folgert, L., Shafer, M. C., & Arauco, T. (2001) *Student background data for 1998–1999 (Grades 6, 7, & 8).* (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 19a, b, c). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Romberg, T. A., Folgert, L., Shafer, M. C., & Arauco, T. (2002) *Student background data for 1999–2000 (Grades 7 & 8).* (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 20a, b). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Romberg, T. A., Shafer, M. C., Folgert, L., Balakul, S., & Lee, C. (2002a) *Teacher background data for 1998-1999.* (*Mathematics in Context* Longitudinal/Cross-Sectional Study Tech. Rep. No. 25). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Romberg, T. A., Shafer, M. C., Folgert, L., Balakul, S., & Lee, C. (2002b) *Teacher background data for 1999-2000.* (*Mathematics in Context* Longitudinal/Cross-Sectional Study Tech. Rep. No. 26). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Schmidt, W. H., McKnight, C. C., Jakwerth, P. M., Cogan, L. S., Raizen, S. A., Houang, R. T., Valverde, G. A., Wiley, D. E., Wolfe, R. G., Bianchi, L. J., Yang, W., King, S., & Britton, E. D. (1998). A summary of *Facing the Consequences*: Using TIMSS for a closer look at United States mathematics and science education. Dordrecht, The Netherlands: Kluwer.

Schoenfeld, A. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education*, *20*(4), 338–355.

Shafer, M. C. (1997a) *Student questionnaire*. (Mathematics in Context Longitudinal/Cross-Sectional Study Working Paper No. 2). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Shafer, M. C. (1997b). *Teacher questionnaire: Experience teaching Mathematics in Context*. (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 8). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Shafer, M. C., Davis, J., & Wagner, L. R. (1997a). *Teacher questionnaire: Background and experience*. (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 9). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Shafer, M. C., Davis, J., & Wagner, L. R. (1997b). *Teacher questionnaire: School context*. (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 10). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Shafer, M. C., & Folgert, L. (2005) *Student attitude inventiory gain score data.* (*Mathematics in Context* Longitudinal/Cross-Sectional Study Tech. Rep. No. 53). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Shafer, M. C., Lee, C. & Folgert, L. (2003) *Teacher background data for 1997-1998.* (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 24). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Shafer, M. C., Wagner, L. R., & Davis, J. (1997). *Student attitude inventory*. (*Mathematics in Context* Longitudinal/Cross-Sectional Study Working Paper No. 7). Madison, WI: University of Wisconsin, Wisconsin Center for Education Research.

Schmidt, W. H., McKnight, C. C., Jakwerth, P. M., Cogan, L. S., Raizen, S. A., Houang, R. T., Valverde, G. A., Wiley, D. E., Wolfe, R. G., Bianchi, L. J., Yang, W., King, S., & Britton, E. D. (1998). A summary of *Facing the Consequences*: Using TIMSS for a closer look at United States mathematics and science education. Dordrecht, The Netherlands: Kluwer.

Shew, J. A. (1996). *Students' beliefs about mathematics and the way it should be learned: A story of struggle and change*. Unpublished doctoral dissertation, University of Wisconsin–Madison.

Stenmark, J. K. (1991). *Mathematics assessment: Myths, models, good questions, and practical suggestions.* Reston, VA: NCTM.

Streefland, L. (1992). Thinking strategies in mathematics instruction: How is testing possible? In R. Lesh & S, J. Lamon (Eds.), *Assessment of authentic performance in school math.* Washington, D.C.; American Association for the Advancement of Science.

Yackel, E., Cobb, P., Wood, T., Wheatley, G., & Merkel, G. (1990). The importance of social interaction in children's construction of mathematical knowledge. In T. J. Cooney & C. R. Hirsch (Eds.), *Teaching and learning mathematics in the 1990's* (pp. 12–21). Reston, VA: NCTM.