"The Math is Different, But I Can Deal": Studying Students' Experiences in a Reform-Based Mathematics Curriculum

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Introduction and Overview

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

We report on the experiences of 9 of these students, drawing on a maximum of 3 semesters of mathematics coursework (Spring 2000, Fall 200, and Spring 2001). We have analyzed their mathematical experiences along 4 dimensions: (1) performance in mathematics, (2) disposition towards the subject, (3) approach to learning the subject, and (4) differences students see between traditional and Core-Plus mathematics curricula and teaching. All of our 9 students reported differences between their past and present mathematics programs as they moved into Core-Plus, but in only 2 cases was there any significant change in performance across the curricular shift.

This Site Relative to the Project as a Whole

Logan High is one of four research sites in a larger project, The Mathematical Transitions Project, that aims to characterize students' mathematical experiences as they move between traditional and reform curricula at two points in the K–16 experience: Entry into high school and entry into college. Both of these junctures appear critical in students' educational experiences, in mathematics and more generally, since many aspects of their experience of schooling and subject-matter change at these points. But recent mathematics curricular reforms inspired by NCTM's Curriculum and Evaluation Standards for School Mathematics (1989) have made it more likely that students will experience discontinuities in mathematics as they move from one level of schooling to another. Most school districts have implemented reform mathematics curricula in a "spotty" manner, that is, at the elementary, junior high , or high school level but not throughout all grades. So in many communities like Logan's, students step into mathematics programs (curriculum and teaching) that call for different ways of thinking, acting, and doing mathematics than those they are accustomed to. The Mathematical Transitions Project was designed to examine and analyze students' reactions in the context of these curricular shifts. The overall design of this project is given below in Table 1.

Table 1A
Basic Research Design

	Type of Curricular Shift	
	Reform to Traditional	Traditional to Reform
Junior high to High school		
High school to College		

Logan was recruited to participate in this study because it provided a relatively good living representation of the "traditional to reform; junior high to high school" cell in the design matrix. Some years ago, the high school mathematics faculty adopted and implemented the Core-Plus Mathematics Project (CPMP) curriculum for the majority of their students. But like many of other high schools in the state of Michigan who have adopted "reform" curricula, Logan maintains a two-track mathematics program. They also teach a standard set of more traditionally-structured courses (Geometry, Advanced Algebra, Functions, Statistics, and Probability, and Pre-Calculus) using textbooks from the University of Chicago School Mathematics Project (UCSMP). But more than 3/4 of the student population uses CPMP materials in their mathematics coursework; the rest take the traditional sequence.

Overview of the Core-Plus Curriculum

Core-Plus is an integrated mathematical sciences curriculum for high schools, consisting of a sequence of three year-long "core" courses for all students and a fourth year course continuing the preparation of students for college mathematics (Hirsch, Coxford, Fey, & Schoen, 1996). Each year of the curriculum features four interwoven strands: algebra and functions, statistics and probabilities, geometry and trigonometry, and discrete mathematics. The content is built around solving problems embedded in real-life situations, with a focus on modeling and calculator-based exploration. The teaching approach emphasizes group-work and learning from peers. More detailed descriptive information on CPMP is available on the program's web-site (www.wmich.edu/cpmp). The U. S. Department of Education's evaluation of CPMP and other mathematics curricula are also available on-line (www.enc.org/professional/federal/resources/exemplary/promsing/documents).

The Junior High Program

All Logan High students complete a relatively traditional mathematics program in the single junior high that "feeds" the high school.[1] "Regular track" 8th graders take Pre-Algebra using a traditional textbook after taking a Math 7 course that focuses mainly on computation with whole and rational numbers.[2] "Advanced track" 8th graders take the same Pre-Algebra course in the 7th grade and then choose either Algebra I or the first year of the CPMP curriculum ("Core I") in the 8th grade. So the curricular shift we target at Logan happens for some students in the 8th grade but for most in the 9th grade when they go to the high school. All information we have gathered at the district level suggests that students' experiences prior to high school (except for the 8th graders who take Core I) are relatively traditional relative to the reform vision articulated in the Standards documents (NCTM 1989; 1991; 2000). Our characterization of the Logan district (junior high and high school) relative to our overall research design is given in Table 1B.

Table 1B
Logan High School in the Research Design

	Type of Curricular Shift	
	Reform to Traditional	Traditional to Reform
Junior high to High school		Logan High Traditional to CPMP
High school to College		

High School Mathematics: Programs, Tracks and Teachers

In this section we describe the mathematics teaching and learning context in the Logan district in more detail. Though the focus is on the high school and its mathematics programs, we begin by describing the "advanced track" 8th grade curricular choice as it governs their experiences at the high school.

"Advanced Track" Students' Choice of 8th Grade Mathematics

Students are identified as "advanced" in mathematics via standardized test scores taken at the end of the 6th grade. Approximately 50 to 75 students are so identified from a yearly cohort of between 250 and 300 students. At the end of the 7th grade, these students are given the choice of taking Algebra I as 8th graders or "Core I." The distinctive quality of

[1] All students, that is, that do not transfer into the district in their high school years.
[2] The current Pre-Algebra and Math 7 textbooks are published by Glencoe.

the CPMP curriculum (especially its integrated content and contextualization in "real-world" situations) is presented to the students in two ways. The Core I teacher at the junior high (who also teaches the Pre-Algebra course to 7th graders) describes the approach in contrast to the traditional high school sequence. To provide the students' perspective, 8th graders currently taking Core 1 also make short presentations based their year's experience with the program. Then the 7th graders make their own choices, usually in consultation with their parents. Typically, these choices generate one section of Algebra I and one section of Core I in the 8th grade. But in the 1998/99 8th grade cohort (the cohort we recruited from), about twice as many students chose the Core option, generating two sections of Core I and one of Algebra I.

Entry into high school mathematics

Nearly all "advanced track" 9th graders elect to stay with the high school mathematics program they have chosen as 8th graders. Algebra I graduates continue on to Geometry in the 9th grade, while Core 1 graduates enroll in Core 2 (called "Integrated Math 2" at the high school—for reasons explained below). Program crossover is rare. All "regular track" students in mathematics enroll in "Integrated Math I" for their next mathematics course—that is, they begin the CPMP program as 9th graders. Some "advanced track" mathematics students do not participate in either of Logan High's mathematics programs, choosing instead to spend half of their school day at the local mathematics and science "magnet" school where they take courses in those subjects and then return to Logan High for the rest of their coursework. The mathematics program at this magnet school is CPMP.

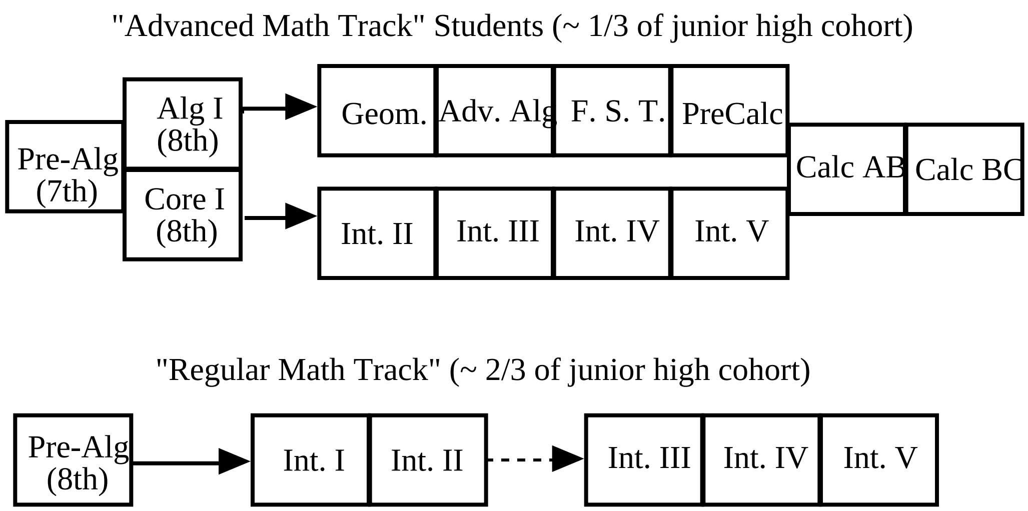
Graduation Requirements. Logan High requires successful completion of only two mathematics courses (e.g., Integrated Math I and II) for graduation, though many students take more. A minimum grade of C– is required to enroll in the next mathematics course in either sequence. Students earning a grade lower than C– in any mathematics course must repeat that course (and earn at least the minimum grade) before they can enroll in the next course in the sequence.

The Semester Structure at Logan

Logan High School instituted "block scheduling" well before we began our project work there. With this organizational structure, students take four courses each semester and change their schedules entirely at mid-year. Each course meets everyday for an hour and 20 minutes, in contrast to 50 minute periods in year-long classes. One argument for "blocks" is that it provides greater flexibility and more diversity in daily classroom activities, permitting deeper access to the subject-matter. Longer class periods allow teachers to teach about 2/3 of a year's content in a semester. But one consequence is that textbooks presenting either a semester or a year of content are either too lean or too rich in content. To convert CPMP curriculum for blocks, the Mathematics Department transformed 4 year-long courses into 5 semester-block units (Integrated Math I – V).

With the flexibility of block scheduling, students interested in mathematics (or any subject) can "double up," and many of our project participants have done so at least once. Students who "double up" in mathematics can take Calculus at Logan; both Calculus AB and BC are offered as semester courses. Though in the past, most Calculus students have come through the traditional mathematics track, that trend may change with the cohort recruited to this project (those who were 9th graders in Fall 1999). The two track mathematics program at Logan is summarized below in Figure 1. The solid arrows indicate entry to high school mathematics; the dotted arrow for “regular track” students indicates the juncture between the required two course sequence and the rest of the optional courses. Throughout, “Int.” stands for “Integrated Math,” i.e., for CPMP courses. Though the Figure does not indicate it, students from the “regular track” could take Calculus if they repeatedly doubled up in mathematics. But that scenario rarely, if ever, happens.

Figure 1
Course Sequences
Logan High’s Two Mathematics Programs



<u>Overview of the Mathematics Faculty</u>

When we began our work at Logan High in Fall 1999, the Mathematics Department was an experienced group of 5 men (Mr. Olive, Mr. Hardy, Mr. Long, Mr. Gold, and Mr. Dale) and 2 women (Ms. White and Ms. Lake), all of whom were supportive of the Core-Plus curriculum. Only Ms. Lake was new to the high school and its mathematics program; she was beginning her second year of teaching at Logan. This group had chosen Core initially, were experienced teaching it, and were generally satisfied with the experiences that it provided students. In Spring 2000, the first year of our official project work, we observed and recruited primarily in courses taught by Mr. Hardy (Int. Math I), Mr. Gold (Int. Math I), Mr. Long (Int. Math II), and Mr. Dale (Int. Math II). In the middle of the Spring 2000 semester, Mr. Dale departed for another position, and his teaching responsibilities were shared out and completed by the rest of the staff. In particular, Mr. Gold took up his Int. Math II section. Mr. Dale was replaced in Fall 2000 by Ms. Dennis, an experienced teacher from the junior high who liked Core but had not taught it prior to coming to the high school. Finally, at end of the Fall 2000 semester, Mr.

Long retired and was replaced by a beginning teacher, Ms. Violet, who had completed her student teaching at Logan with Ms. White. So by January 2001, the Mathematics faculty at Logan consisted of 3 men (Mr. Olive, Gold, and Hardy) and 4 women (Ms. White, Lake, Dennis, and Violet), where Lake, Dennis, and Violet were all learning their way through the CPMP curriculum. With few exceptions, the teachers taught courses from both the CPMP and traditional sequence, both and after the recent staffing turn-over.

The Community and Student Population

Logan High School serves a suburban area on the edge of medium-sized Michigan city. The community is largely middle class but not affluent. Employment in the area includes a mix of blue-collar and white-collar jobs, with many in the service sector. In the recent past, the local economy had been dominated by relatively high-wage manufacturing jobs, but that work had declined in recent years. The student population at Logan is primarily white with small numbers of African-American, Asian-American, Native-American, and Hispanic students.[3] Overall, Logan High enrolls between 1000 and 1100 students, with a freshmen class of between 250 and 300 students. About 4% of the total enrollment qualify for free or reduced-cost lunches. The majority of students go on to some form of higher education, though many enroll in 2-year colleges and take a job at the same time. Frequently, college-bound students choose to enter local 2-year colleges first and then transfer to larger 4-year colleges and universities thereafter.

As part of our data collection activities (see below and Smith & Berk [2001] for much more detail), we observed mathematics classes where our participants were enrolled on a frequent and continuous basis. From observations over the course of 3 semesters, we have seen that many Logan students struggle to see the importance of schooling, or mathematics specifically, in their lives. While overall classroom behavior is fine, we are often struck by the weak engagement of students, particularly those in the regular track. We do not think this “problem” makes Logan High exceptional in any way; student engagement is an issue in schools in many (if not most) U. S. communities. However, we do see somewhat more skepticism about the purposes of schooling and weaker engagement at Logan than at Prescott, the other high school site involved in this project (see Jansen & Herbel-Eisenmann, 2001).

Research Questions & Data Collection

Our conceptualization and exploration of students’ mathematical experiences, at Logan High and more generally in this project, have led us to pose, revise, and restate our research questions in a series of cycles (see Smith and Berk, 2001 for details). In our recent analyses of data from the Logan site, we have focused on three main questions:

- What do students notice as different as they move from a relatively traditional junior high school mathematics curricula and teaching into a Standards-based high school program?

[3] In 2000, these proportions were: 90% Caucasian, 4% Asian-American, 3% African-American, 2% Hispanic, and 1% Native American

- In this context, who experiences mathematical transitions and why?
- What factors shape the experience of mathematical transitions (when they occur)?

Our analyses relative to these questions draw on the experiences of students who entered Logan High as 9th graders in the Fall of 1999, though we did not begin to work with them until the Spring 2000 semester.[4] At this writing, those students are completing their 4th semester of high school—and due to block scheduling—their 2nd to 5th mathematics course. We have collected data about their mathematical experiences for 3 full semesters of participation. During this time we have interviewed them (2 to 3 times each semester), collected their grades and work from their mathematics courses, learned about their educational and career goals, assessed their beliefs about mathematics and about learning mathematics, and tracked their weekly experiences in math class in their journal entries. In our analyses of their mathematical transitions, we focus on (1) changes in their mathematics achievement, (2) differences they note between junior high and high school mathematics, (3) changes in their disposition toward mathematics, and (4) changes their approach to learning mathematics. Smith & Berk (2001) provide an extensive discussion of the rationale and conceptualization of each of these 4 dimensions.

The Research Sample at Logan High

As at other sites, we wanted to recruit a diverse group of 25 students who were freshmen at Logan High in the Fall of 1999. We had learned about the dual-track mathematics program and the choices that “advanced” track mathematics students were asked to make before their 8th grade year. Though this complicated our research and recruitment (because “advanced” track students were introduced to the Core-Plus curriculum in junior high school), we felt that it was important to sample both “regular” and “advanced” track students, in about the equal proportions to the cohort population (~1/3 advanced, ~2/3 regular). We were relatively successful, though not completely so, in achieving this goal.

Logan High was the last of the 4 project sites that agreed to participate in the Mathematical Transitions Project. So work at this site was delayed somewhat relative to other sites. We used the Fall 1999 semester to get to know the mathematics program at Logan, the nature of the Core-Plus curriculum, the mathematics faculty at Logan, the overall school climate, and the students who might participate. The core activity in Fall 1999 was classroom observations of different teachers teaching Integrated Math I and II classes.

By February 2000 we began to recruit student volunteers. We identified the Integrated Math II classes where “advanced” track freshmen were taking their first high school mathematics course and two of the three Integrated Math I classes that were primarily filled with “regular” track freshmen. About midway through the semester, after these classes had gotten familiar with our presence, we described the project, its goals, activities, and opportunities for students to these classes. As students expressed interest, we met with them in small groups to explain the duties and the rewards of participation.

[4] Work in the Fall 1999 semester was limited to informal work in CPMP classrooms, to get to know the matehamtics faculty and the curriculum itself.

By the end of the semester, 26 freshmen had volunteered (10 from the "advanced" track, and 16 from the "regular track"), and we began data collection with this sample.

By the beginning of the Fall 2000 semester, we had some attrition among our "regular" track participants; three of the 16 did not enroll at Logan again, and one other student came to school very inconsistently and eventually dropped out. Since this dropped our "regular track" sub-sample to 12, we recruited again this semester in one class of Integrated Math I and two freshmen from that class became participants. Thus our overall site sample became 24 Logan students (22 were freshmen in Fall 1999; 2 were freshmen in Fall 2000). Ten were in the "advanced" mathematics track with 14 in the "regular" track. In the "advanced" group, 6 students were male; 4 were female. In the "regular" group, 6 students were male, 8 were female.

Of those 24 students we selected 9 students—5 "advanced" track and 4 "regular" track—to analyze in some detail for this conference. The reduced number of students (9 of 24 overall) simply indicates only the difficulty of this analysis, as we were developing our conceptualization of mathematical transitions while we analyzed data from individual students. Table 2 below describes the mathematics courses taken by these students from 7th grade forward. The 5 students listed above the bold line are "advanced" mathematics students, who took Core I in the 8th grade. As Table 2 indicates, this group contained four students (ST, DL, LH, and AW) who "doubled-up" in mathematics. One student, DS, repeated Integrated Math I as a 10th grader because she failed that course in the Spring of her 9th grade year.

Table 2
Sample Students' Mathematics Coursework
(junior high into high school)

Student	**Gender**	**7th grade**	**8th grade**	**Fall 9th**	**Spring 9th**	**Fall 10th**
ST	M	Pre-Alg	Core I*	No Math	Int Mth 2	Int Mth 3
DL	M	Pre-Alg	Core I*	No Math	Int Mth 2	Int Mth 3
TD	M	Pre-Alg	Core I*	No Math	Int Mth 2	No Math
LH	F	Pre-Alg	Core I*	No Math	Int Mth 2	Int Mth 3
EJ	F	Pre-Alg	Core I*	No Math	Int Mth 2	No Math
MB	M	Math 7	Pre-Alg	No Math	Int Mth 1	No Math
MJ	F	Math 7	Pre-Alg	No Math	Int Mth 1	No Math
DS	F	Math 7	Pre-Alg	No Math	Int Mth 1	Int Mth 1
AW	F	Math 7	Pre-Alg	Int Mth 1	Int Mth 2	Int Mth 3

* junior high school name for the first course in CPMP.

Results

Ultimately, we want to describe the mathematical experiences of all our project participants, at Logan High and at our other research sites, along four main dimensions: (1) change in their mathematical performance across the curricular shift (reform to traditional or vice-versa); (2) change in their disposition toward mathematics, (3) change in their approach to learning mathematics, and (4) the differences that they notice and report between the two curricula. In this paper, however, we focus primarily on changes in mathematics performance and mathematical differences reported, because (i) performance is an important dimension of transition, and (ii) we have focused considerable energy developing a coding scheme for differences and scoring our data. Then we follow with our current assessment of who has (and has not) experienced a mathematical transition—using more qualitative and less precise measures of changes in disposition and learning approach. As described elsewhere (see Smith & Berk, 2001), we have tentatively adopted the view (and the resulting "decision rule") that significant change on any 2 of the 4 dimensions above is necessary and sufficient evidence for a mathematical transition. While that view (and model) may change, it frames the analysis and discussion presented here.

Mathematics achievement

One basic question commonly asked is whether fundamental changes in mathematics curricula are associated with changes in students' performance in mathematics as they move between those curricula. Indeed, volleys between reformers and critics in the "Math Wars" are often framed in performance terms. Table 3 below provides the relevant performance data for the 9 students in the sub-sample. We include, when available, both mathematics grades and overall grade point averages (GPA) because we are interested in studying changes in performance in mathematics against the backdrop of overall academic performance. Tracking changes in math grade and GPA allows us to separate changes in the former that are part of a general academic advance or decline from those that are not. Currently, our decision rule for "significant" change in mathematical performance requires that the difference between the change in mathematics grade (before & after) and the change in GPA (before & after) be $\geq .5$ (see Smith & Berk [2001 for details).

Table 3
Sample Students' Mathematics Achievement
(Junior High into High School)

Student	Gender		7th grade	8th grade	Fall 9th	Spring 9th	Fall 10th
ST	M	Course	Pre-Alg	Core 1	No Math	Int Math 2	Int Math 3
		Grade	3.9	4.0		4.0	4.0
		GPA	3.92	3.92		4.0	3.92
DL	M	Course	Pre-Alg	Core 1	No Math	Int Math 2	Int Math 3
		Grade	3.5	3.7		3.7	3.7
		GPA	3.45	3.62		3.63	3.67
TD	M	Course	Pre-Alg	Core 1	No Math	Int Math 2	No Math
		Grade	4.0	4.0		4.0	
		GPA	4.00	3.99		4.0	4.0
LH	F	Course	Pre-Alg	Core 1	No Math	Int Math 2	Int Math 3
		Grade	3.4	4.0		4.0	4.0
		GPA	3.83	3.92		4.0	4.0
EJ	F	Course	Pre-Alg	Core 1	No Math	Int Math 2	No Math
		Grade	3.9	3.3		3.0	
		GPA	3.91	3.90		3.75	3.83
MB	M	Course	Math 7	Pre-Alg	No Math	Int Math 1	No Math
		Grade	2.0	4.0		3.7	
		GPA	2.60	2.91		2.50	2.25
MJ	F	Course	Math 7	Pre-Alg	No Math	Int Math 1	No Math
		Grade	3.3	3.7		3.7	
		GPA	3.18	3.45		3.75	3.75
DS	F	Course	Math 7	Pre-Alg	No Math	Int Math 1	Int Math 1
		Grade	2.2	1.7		0.0	3.0
		GPA	2.43	2.36		1.13	N/A
AW	F	Course	Math 7	Pre-Alg	Int Math 1	Int Math 2	Int Math 3
		Grade	1.35	3.7	3.7	3.7	
		GPA	2.65	3.48		3.88	3.92

The entries in Table 3 show that most of these 9 students remained "good" students across the curricular shift (8th to 9th grade). The "advanced" track students were consistently good across all grades (7th–10th) while the "regular" track students generally improved their performance from the 7th to the 8th grade. DS, the single exception to this pattern, did poorly in both 7th and 8th grade mathematics and then "bottomed" out in 9th grade Integrated Math I. She stopped coming to class and earned a "0.0" for the course. Relative to our formal criterion stated above, only EJ ($\Delta = .59$) experienced a "significant" change in mathematical performance in her first introduction to CPMP curriculum.

Among the 5 "advanced" track students, there was little change in performance in mathematics (and across school subjects more generally) as they moved into high school. They were "A" to "B+" students in their traditional 7th grade Pre-Algebra course (and generally), and their achievement did not change much when they moved into Core I as

8th graders. Moreover, their grades were unaffected by their entry into high school—again, both in mathematics and more generally. Two small changes, however, are noteworthy. LH, generally an "A" student overall, scored consistently better (if marginally so) in mathematics after the shift into CPMP. This performance change is consistent with some of the differences LH reported between Pre-Algebra and Core-Plus (see below). By contrast, EJ has experienced small changes in the opposite direction. Though her overall GPA has changed very little, her mathematics achievement slipped a bit with each step away from her traditional Pre-Algebra course in the 7th grade. But overall these students' academic performance (especially in mathematics) was surprisingly constant from 7th to 10th grade.

A different, if less consistent, pattern held for the "regular" track students. The greatest change in mathematical and academic performance took place between 7th and 8th grade, and the change was upward for 3 of the 4 students, and significantly upward for 2—MB and AW. Recall that both of these mathematics courses were traditional in nature. The 8th grade level of performance was then generally maintained into high school, especially in mathematics. This improvement was dramatic for AW and MB and more modest for MJ.

AW's improved performance from 7th to 8th grade was very large in mathematics but also reflected more general academic improvement. Her GPA went up by more than 3/4 of the point. As a high school student, she represents an interesting case for us as she has declared on many occasions that she "hates math" though she "doubled-up" in the subject as a 9th grader. Her stated rationale for this choice was that her father had convinced her that mathematics was important. On the other hand, we also have seen evidence that she enjoyed her demonstrated ability to rise to the challenge of the subject—despite her vocal complaints. That said, there is little evidence that her disposition toward mathematics <u>changed</u> across the curricular shift (i.e., in her move into CPMP). We are currently trying to probe the nature of her views of mathematics. We suspect that her surface comments may hide important issues underneath.

MB's experience is also interesting as he represents the only case among these 9 students where performance in mathematics was consistently and substantially higher than overall academic performance. Mathematics became an academic strong point for MB in 8th grade and remained so in 9th grade. For our interviews, we know part of this pattern is due to his struggles with print (written text). We do not yet know the exact nature of his difficulty, but he represents an interesting case for a curricula that demands a greater role for speaking, reading, and writing mathematics than has traditionally been the case. Though we was quite successful in Integrated Math I as a 9th grader, we know from recent interviews that he has begun to struggle with the language demands in Math II.

DS is the only student of the group who has consistently struggled academically—both in general and in mathematics. She was not academically successful before the shift into Core-Plus (and into high school more generally), and she struggled thereafter. Overall, it is not clear how much of her struggle with school reflects academic difficulties. DS has a difficult home life and questions, at least at time, the positive role that school could play in her life. She failed Integrated Math I completely as a freshman due in part to a "blowup" with her teacher. Interestingly enough, she came back the next semester and performed much better in the same course with the same teacher. Unfortunately for us, she left Logan High in the following Spring semester, so it appears we will not be able to trace her experiences through her high school years.

In sum, there is little evidence of change in mathematical performance across the curricular shift at Logan, whether it took place in the 8th grade (for "advanced" students) or in the 9th grade. Most were good students in mathematics before and after their entry into the CPMP curriculum. In only one case was there a clear pattern of change over time (EJ; downward). The greatest performance changes took place among "regular" track students, but they happened in junior high, before they were introduced to CPMP. These changes, including DS's downturn and recovery as a 10th grader, may be more due to students developing a more mature attitude toward schooling than anything specifically mathematical.

Reported Differences between Junior High & High School Mathematics

As we have suggested elsewhere (Smith & Berk, 2001), any analysis of what students notice as different in the movement between mathematics programs must discriminate between general changes in how students experience their school lives and changes specifically tied to mathematics. The Mathematical Transitions Project has attempted to mind that issue by distinguishing between "general developmental changes" and "mathematical differences." General developmental changes are differences that students experience and report about their lives in general at different institutional levels of schooling, e.g., junior high vs. high school or high school vs. college, but that have little to do with their mathematical experience *per se*.

General developmental changes

At Logan High, many participants told us, in our initial interviews with them (Spring 2000) that their orientation toward academics was quite different than it had been in junior high school. Many reported that they did not pay very much attention to their grades in 7th and 8th grade. Now, as high school students, they stressed that their grades mattered more, e.g., for college admission, and so they were more attentive to their overall performance. They did not see this only as a change in themselves as students. They also saw the high school environment as different from junior high, and they were changing within that environment.

For example, they reported that their teachers continually reminded them that their future opportunities ahead were influenced by their current academic performance. Coupled with their hopes and wishes for life after high school (most of our participants expressed some hopes or plans for some college education), these reminders appeared to have a strong general effect on their classroom experiences. They made the students more attentive to their performance but did not directly orient how they went about learning. They felt that teachers expected them to accept more responsibility for whether they learned or not, and, in general, they welcomed the inherent challenges in finding ways to organize themselves to achieve. That said, it did not necessarily follow that they became more independent learners. Our observations indicated that most remained dependent on their teachers to show them what they should do to learn the content.

Mathematical differences

Against this backdrop of these general developmental changes, our 9 students also reported many differences between their Core-Plus mathematics courses and their experiences in mathematics prior to Core, especially in junior high school. Overall, we did not see clear differences between the descriptions of "advanced" mathematics track students (who first used CPMP as 8th graders) and those of the "regular" track students. There were both variations across individual reports and substantial commonality in their descriptions. Also, how students experienced the Core-Plus curriculum was influenced, often substantially so, by the particular teacher involved. Indeed, it proved difficult here, and at Prescott (Jansen & Herbel-Eisenmann, 2001), to focus students' attention on issues other than their teacher. If things were going well, students tended to credit their teachers; if things were going poorly, they blamed them. Our ability to report differences between "old" and "new" mathematics was due in part to our patience as interviewers in getting students to focus on what they were doing to learn, separate from the guidance their teachers were offering. Table 4 presents our current analyses of the most commonly reported mathematical differences from this group of 9 students. For ease of discussion, we have grouped together differences that seem closely related.

Table 4
Frequently Reported Mathematical Differences

Difference	Who reported?
Core texts looked different, e.g., no pictures, no highlighted boxes.	AW, DL
Mathematical terms in Core books can be difficult to understand.	EJ
Typical problems are different in Core; more are "real-world" or based in "situations."	ST, AW, DL, LH, AD
Core problems are often harder to understand than traditional problems, e.g., what the problem is asking for.	AW, DS, LH, MB, AD, MJ
Core textbooks do not typically provide examples or highlighted procedures for solving problems.	AD, DS?, AW?
Homework assignments in Core are not repetitive like assignments in traditional mathematics (the "50" problems issue).	AW, ST, MJ
Core problems can require that you explain to yourself what to do.	DL, MB
Contextual problems in Core are more demanding; make you think, decide how to solve.	AW, DS, ST, DL, AD
Core problems ask you to explain how you solved the problem so there is more writing involved.	DS, LH
By contrast, traditional problems often required memorization.	DS, LH
Mathematical content in Core is more diverse	AW
More group work in Core, but mostly in Core 1.	AW, ST, AD

More use of the graphing calculator in Core.	DS
Core teachers discuss alternative solutions; traditional teachers show you the one way.	MB
Core classes at the high school meet longer.	MB
Homework is more frequent in high school.	AW, DS
Core classes at the high school use a common final exam, e.g., in Core 1.	MB

By far, the most important cluster of differences concerned the nature of problems typically found in the Core-Plus curriculum, relative to problems in prior mathematics classes. We identify this cluster as important by the number of differences that were directly related to typical problems and by the number of students who mentioned one or more differences in this cluster. These students noticed that mathematical issues were typically embedded in realistic problem situations; problems were often harder to understand because you had to think about the embedding situation; homework assignments did not include many problems of the same type; and Core texts did not provide model solutions, so students found they had to develop their own solutions. These features were reported in contrast to those the students associated with traditional problems that were (1) usually stated in numerical or symbolic terms or were more contrived "word problems;" (2) learned along with a general solution method or procedure; (3) solved in collections of very similar problems; and (4) required little thought to solve if the general procedure was known. We take these differences and corresponding frequencies as substantial evidence that the content of the CPMP curriculum has influenced students' mathematical experiences, as these differences are explicit in the design principles and in the curriculum itself.

We find it somewhat surprising that other salient features of the CPMP curriculum drew so little comment. Only one student commented about the greater variety in the mathematical content, and another one about increased use of graphing calculators.[5] Three students mentioned increased group work, but two of them (ST and AD) explained that this was more descriptive of Core I in the 8th grade than their high school experience. Though we saw some form of group work in every Logan math class we observed, the modest number of reports from these 9 students were influenced by two factors: (1) the use of small groups in junior high classes and (2) the variability at the high school in what "group work" meant. In some classes, "working in small groups" simply meant "sitting in small groups." We could continue to seek explanations for each low-frequency difference, but given our relatively small sub-sample of 9, it seems sensible to await the analysis of all 24 Logan participants.

Mathematical transitions

Table 5 presents our best current sense about how to assess our 9 students' mathematical experiences along the 4 dimensions identified earlier. This "score card" represents a very

[5] Our classroom observations showed the relative emphasis on graphing calculator use varied markedly across teachers. Also, we are seeing more report and discussion about the role and importance of thest tools in your Year 2 interviews.

preliminary and tentative analysis (as represented explicitly in the question marks in some cell entries). We include short comments under each cell score whenever appropriate. As we have found at other project sites, it is difficult to assess students' disposition toward mathematics, without simply reflecting back how they feel about their current performance or teacher. Our entries in that column represent our decision to report a "no" for change in disposition unless we have evidence to the contrary. Likewise, we are only learning how to ferret out evidence of changes in learning approach, as our students are typically not conscious of their patterns of study and thinking and changes in them.[6] We fully expect that our analyses will change as we work over our existing data more deeply and gather more.

Table 5
Mathematical Transitions by Student

Student	Δ Math Performance	Δ Math Disposition	Δ Learning Approach	Significant Differences?	Mathematical Transition?
ST	No	No	Yes?	Yes	Yes?
DL	No	No	Yes	Yes	Yes
			Explain to myself		
TD	No	No	No	Yes	No
LH	No	No	Yes?	Yes	Yes?
			Question the teacher		
EJ	Yes	No	No	Yes	No?
	Core I				
MB	No	No	No	Yes	No
MJ	No	No	No	Yes	No
DS	Yes	No	Yes?	Yes	Yes
	Core I repeat		Semester 2 → 3		
AW	No	No	No	Yes	No
		"Hate math"			

Currently, we are comfortable only in the cases of DL and DS asserting that a mathematical transition has taken place. Though we are unsure that DS's ways of learning changed when she retook Core I, her performance changed dramatically, and she articulated numerous differences between traditional and Core-Plus mathematics. DL's case earned a "yes" for transition because the shift in the nature of typical problems described above led him to develop a different way of working on those problems—that is, a change in learning approach. He clearly articulated that he had to "explain the problems to himself" orally in Core I to understand the situations and decide what to do

[6] This contrasts with our data and analysis of college students who much more control over their study time and therefore must make their own decisions about how to learn the content they are studying.

to solve the problems. Though other students may have changed how they worked on Core-Plus problems, DL was the one student who articulated a distinct change in approach clearly.

In two other cases (ST and LH), we remain unsure whether their learning approach changed in their CPMP mathematics classes and therefore whether we should score them as cases of mathematical transition. ST reported that he began to do more work individually (even when sitting in groups) when he came to feel in Core I that group was making him to reliant on the work (and understandings) of his peers. This appears to count as a genuine change in learning approach, but we are unsure how "significant" a change it has been. LH reported that she would arrive at school early and ask her Core I teacher questions about what she did not understand in the current assignment. If this were a totally new behavior for her, we would be comfortable inferring that new demands in the CPMP curriculum caused her to approach her learning of mathematics differently. But the data do not support such a simple explanation. LH actually reported that she sought time with her Pre-Algebra teacher away from class to pose questions, but he was not generally available. So her interest in devoting extra time to one-on-one questioning of her teacher predated her move in the CPMP curriculum.

An alternative perspective on this summary data is to look down the columns and thereby consider the experiences of the group as a whole. Though they come out in different ways and at different times from different students, all 9 students reported what we consider important mathematical differences. That said, we are currently trying to develop consistent analytic methods for assessing "significance" among reported differences, here and at other sites. As judged by "learning approach," 5 of 9 students have adjusted the differences they reported without making major changes in how they go about learning mathematics (or at least we have failed to uncover evidence of such changes). None of the 9 have convinced us that their attitudes toward mathematics changed in any clear way—attitudes which may be generally positive or much less so (AW). So thus far, there are two ways that Logan High students have experienced mathematical transitions: (1) via declines or gains in performance, coupled with differences, and (2) via changes in learning approach, coupled with differences.

Conclusions and Discussion

The purpose of the Mathematical Transitions Project, as the larger context of the work reported here, is to characterize students' experiences of Standards-based mathematics in close relation to more traditional forms of mathematics curriculum and teaching. One empirical pattern that is well-represented in the work at Logan High is the adaptability of students. As our title suggests and our data on these 9 students indicate, students can be surprisingly adaptable to educational changes that seem dramatic to adult professionals, e.g., mathematics educators—whether they are supportive or critical of Standards-based reforms. Overall, the data reported here hardly constitute a picture of a "shock wave" or anything like the dramatic effects on students that are often hinted or directly alleged in current "Math Wars" debates.

This is not to say that the stories of these 9 Logan High students show no impact of reform curricula, and of the CPMP curriculum in particular. As the data on mathematical differences show, students notice many of the most important design characteristics of Standards-based curricula that distinguish them from more traditional programs. In particular, we find it important (and sensible) that many of these differences cluster around the nature of typical problems, their collection into daily assignments, and the kind of thinking they require. For students, as for curriculum developers, these are non-trivial aspects of mathematics education. And we find complementary evidence of impact from this aspect of reform at other project sites as well (see Jansen & Herbel-Eisenmann, 2001; Smith. Lewis, & Lazarovici, 2001; Star, 2001).

We also find it interesting that we have <u>not</u> found that movement between traditional and reform curricula is associated with changes in performance in mathematics at either high school site (Jansen & Herbel-Eisenmann, 2001). Though we should be cautious about our claims because we are dealing with such small numbers (around 25 students per site), grades do not appear to be a major dimension of effect in the early high school years. Good students, for example, seem to remain good students even when they have strong reactions to curricular changes. This is significant because it points our attention at other dimensions of impact—in our conceptual scheme to issues of disposition toward mathematics and approach to learning.

In advancing our work at the Logan High site, we clearly have to expand our analysis to all 24 participating students (and this work is currently underway). But we also face challenges of a more conceptual and methodological nature: Questions about the nature of our data and the possible interpretations we can give of them. These include: (1) how can we surface students' disposition toward the subject of mathematics (not their disposition towards their teacher), (2) are high school students sufficiently aware of how they go about learning mathematics to report it back to us, (3) how can we effectively judge "significance" to students with respect to the differences that they report between reform and traditional curricula? We have relevant data (not reported here) that help us to address the substance of these questions, but in many cases the data do not seem to permit easy conclusions and raise thorny issues of interpretation. Fortunately, the three year duration of this project allows us to go back to our participants many times in our efforts to understand their mathematical experience.

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