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Homework as Test Preparation: Its Promise and Efficacy

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In this paper we report on the process, outcomes, and impact of a weekly homework assignment for which students write about the mathematics they do in their everyday lives. Data from 17 fifth-grade students suggest that after doing the assignment for a full school year, students clearly communicated their beliefs about the assignment having improved their mathematical abilities and their overall confidence with doing mathematics, communicating about mathematics, and taking tests involving mathematics. The assignment also alleviates pressure on teachers to "teach to the test" and to sacrifice valuable instructional time for test preparation. The assignment may prove to be an effective tool for enhancing students' mathematical skills, as well as their test-taking efficacy.

The importance of a relevant curriculum for student learning is certainly not a new idea. Over a century ago Dewey (1902) wrote about the tension and possible resolve surrounding the issue of teaching the child versus teaching the subject. He considered the arguments pertaining to the questions of what knowledge children need both in and out of school – a quandary that persists today. Since Dewey, others such as Brown, Collins, and Duguid (1989), the National Research Council (Bransford, Brown, & Cocking, 2000; Donovan & Bransford, 2005; Donovan, Bransford, & Pelligrino, 1999) have published seminal works discussing the importance of embedding learning in students' experiences in order for students to acquire "useable, robust knowledge" (p. 32).

> Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom. (Brown, Bransford, & Cocking, 2000, p. 10).

The impact and implications of a disparate structure between school learning and critical real world knowledge has been studied in the context of mathematics more than any other subject area (e.g., Davis & Maher, 1993, 1997; Gravemeijer, 1997). For example, in the 1970s Freudenthal and his colleagues established Realistic Mathematics Education, which was premised on the idea that if learning mathematics is to be motivating and of value, it must be connected to children's reality and should be relevant to society (Freudenthal, 1973). Using realistic contexts that students could at least imagine if not experience became one of the determining characteristics of this approach to mathematics education (Van Den Heuvel-Panuizen, 2003).

In the mid-1980's, Carraher, Carraher, and Schleimann (1987), introduced the mathematics education community to young Brazilian street merchants whose facility with in situ computations and problem solving with money far exceeded their ability to succeed with school mathematics. This research sent a clear message. We needed to reexamine our definition of what makes a successful young mathematician and what is important for children to learn, to know, and to communicate within a school mathematics program. Soon after, the Cognition and Technology Group at Vanderbilt (1997) brought programs such as The Adventures of Jasper Woodbury to the conversation. This work was premised in an anchored-instruction approach to teaching and learning mathematics, whereby learning and instruction were anchored to problem-based environments that were meant to motivate students and to offer them reasons to learn mathematics.

More recently, studying the ways in which marginalized populations such as racial minorities and students from low-income families are removed from typical textbook scenarios has contributed to appeals for relevant curricula that embed principles of Social Justice and equity in the classroom. Significant to the findings of this scholarship is that context matters when it comes to urban students engaging and succeeding with school mathematics (Ebby et al., 2011; Gutstein, 2003; McNair, 2000). Regardless of the context, the message has remained the same in over a century's worth of literature: Children need and deserve culturally relevant schooling that builds on their informal mathematical knowledge and motivates their learning.

Responsively, many textbook publishers and researchers have endeavored to encourage pedagogy and write and publish curriculum that reflects students' real-life circumstances (e.g., Carpenter, Fennema, Franke, Levi & Empson, 1999; Romberg, 1997-1998; The University of Chicago School Mathematics Project, 2007; Treffers, 1991), thus hoping to generate purpose, interest, and innovation (Freudenthal, 1977) among learners. The current era of high-stakes testing, however, has forced an alternate dimension and widespread pedagogy into the mathematics classroom – teaching-to-the-test. Although teachers are encouraged to believe that students who are flexible problem solvers and proficient communicators will fare better than those who attempt to memorize problem-types and procedures (Hartweg & Heisler, 2007; National Council of Teachers of Mathematics, 2000; National Governors Association, 2010; Turner, 2009), teaching-to-the-test practices still seem to hijack much of teachers' instructional time, and consequently, students' learning time (Turner, 2009).

With this paper, we hope to expand upon the body of literature pertaining to the importance of relevant curriculum for mathematics learning to include test preparation. Specifically, we contextualize, present, and discuss findings from fifth grade students doing a "Math in Everyday Life" (MIEL) homework assignment for the duration of a school year. For this assignment, every Monday students turned in a written account of how they used mathematics authentically and in their everyday lives outside of school.

Research Context and Questions

The motivation for the current work came from our own experiences with, and a review of literature that spoke to, the fact that the "real-world" problems found in middle-school mathematics textbook series were actually unrelated to the lives of many of the children who use them (Ebby et al, 2011; McNair, 2000; Teich, Nelson, McEhaney, & Lita, 2000). That is, although many modern mathematics textbook series attempt to *reflect* the lives of middle level students, the generic and contrived problems found within them are not the same as authentic situations that are in real-time, and are unique to and current in students' lives (Ebby et al., 2011; Gravemeijer, 1997). These latter, real-time situations are found in students' in situ mathematical activities such as shopping, playing sports and videogames and require spontaneous and functional applications of mathematical knowledge and skills.

Given the amount of literature pertaining to the importance of a relevant curriculum for children's learning of mathematics; and given middle level teachers' concerns about their students' test results, we wondered what impact the MIEL would have on local fifth grade students' preparation for and results of the Measures of Academic Progress (MAP®) test, which they take three times throughout a school year – Fall, Winter, and Spring. MAP® is an electronically administered standardized test published by the Northwest Evaluation Association (NWEA, n.d.). More specifically, would students' mathematical confidence, competence, and test scores improve as a result of doing a weekly homework assignment for which they had to report on how and when they used mathematics out of school?

Methods

Participants

Seventeen fifth-grade students at a suburban middle level public school in an economically diverse school district participated. There were 10 boys and 7 girls. One student was Hispanic, two were African American, and the rest were Caucasian. Seven students had IEP's, all for ADHD. All students had worked exclusively with a textbook-based mathematics program since first grade.

Data Sources and Analysis

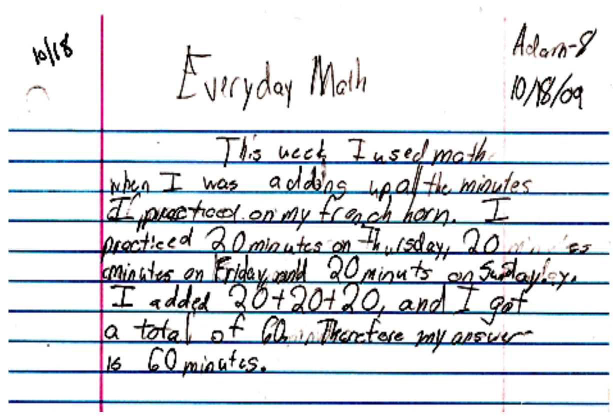
The MIEL. In the first week of the school year, the teacher introduced her students to the MIEL. She told them that each Monday they would hand in a unique description of how and when they used mathematics outside of school. She explained to them that they must describe the situation and do the necessary mathematics. Then, they had to explain how they did the mathematics from a conceptual rather than procedural perspective. She gave examples such as tipping, shopping, and cooking to illustrate her points. She also showed examples of mathematical explanations that were insufficiently conceptual. For example, if a student wanted to explain how she added 24 and 13, setting up a vertical algorithm and adding columns of digits would not suffice. This is because the algorithm does not explain why 24 plus 13 is 37, only how to add them together digit by digit. Rather, she expected students to explain something like: 13 is the same as 10 plus 3. So, I can add 24 plus 10, which is 34 and then I can add on the other 3. Thirty-four plus 3 is 37.

The teacher also encouraged students to involve their parents and other family members. She told students that they would have opportunity to share their work on Mondays during math time but the submissions would not be graded per se. Rather, the submissions would be recorded as "done" or "not done." The teacher also explained that the assignment was exclusively for homework and no class time would be provided for working on it, only for sharing it.

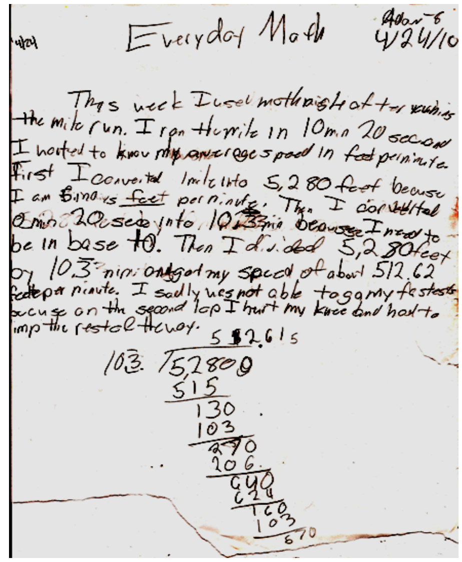
Moreover, the teacher told her students that the mathematics they were to write about was to be authentic to their environments and lives and thus, did not need to align with the ideas and concepts being discussed and practiced currently in their mathematics class. She emphasized that the assignment was about enriching awareness of the mathematics students do in their everyday lives and about applying the mathematical skills and concepts they study in school. In effect, the curriculum should be preparing students for mathematical challenges in and out of school (Turner, 2009). Sample MIEL's can be found in Figures 1 and 2.

Figure 1. **Student's progression in complexity with the MIEL**

In particular, the MIEL provided a regular and meaningful venue for students to apply and to practice their mathematical knowledge and skills, as well as their problem solving and communication processes.

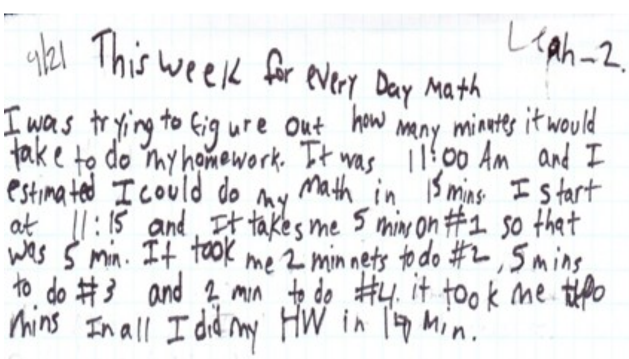


"This week I used math when I was adding up the minutes I practiced on my French horn. I practiced 20 minutes on Thursday, 20 minutes on Friday, and 20 minutes on Saturday. I added 20 + 20 + 20, and I got a total of 60. Therefore my answer is 60 minutes."

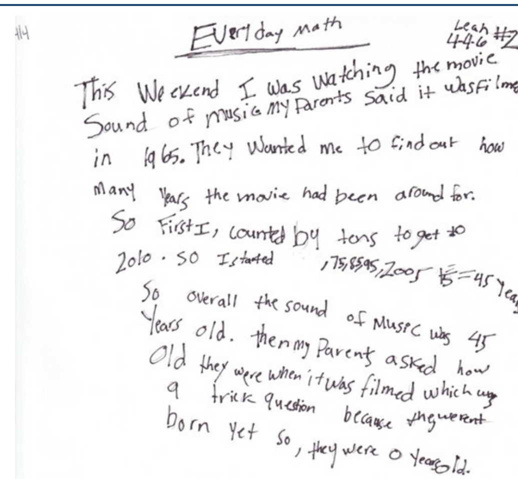


This week I used math right after running the mile run. I ran the mile in 10 min 20 seconds. I wanted to know my average speed in feet per minute. First I converted 1 mile into 5,280 feet because I am finding <u>feet</u> per minute. Then I converted 10 min 20 sec into 10.33 min because I need to be in base 10. Then I divided 5,280 feet by 10 min and got my speed of about 512.62 feet per minute. I sadly was not able to go my fastest because on the second lap I hurt my knee and had to limp the rest of the way.

Figure 2. **Leah's progress in clarity with the MIEL**



"I was trying to figure out how many minutes it would take to do my homework. It was 11:00 a.m. and I estimated I could do my math in 15 mins. I start at 11:15 and it takes me 5 mins. on #1 so that was 5 min. It took me 2 minnets to do #2, 5 mins to do #3 and 2 min to do #4. I did my HW in 14 min."



"This weekend I was watching the movie Sound of Music. My parents said it was filmed in 1965. They wanted me to find out how many years the movie had been around for. So first, I counted by tens to get to 2010. So I started 1965, 75, 85, 95, 2005 + 5 = 45 years. So overall the Sound of Music was 45 years old. Then my parents asked how old they were when it was filmed which was a trick question because they weren't born yet so, they were 0 years old."

Data and analysis. MIEL's were collected from all students weekly beginning the third week of school, with the last MIEL collected mid-May. Each MIEL was coded as "poor," "satisfactory," or "excellent" with respect to clarity. "Poor" clarity responses involved nonsensical statements and a general lack of accuracy in describing any computation. "Satisfactory" responses were accurate in describing the computation, but did not extend beyond the basic nature of the problem (e.g., describing addition as one number plus another number results in a third number). "Excellent" responses were accurate in describing the computation, and also extended the description to include additional ways of describing the computation or more detail about it.

Each MIEL submission was also coded as "basic" or "advanced" with respect to mathematical complexity. "Basic" complexity included addition or subtraction of whole numbers, whereas "advanced" complexity included multiplication, division, working with decimals and fractions, and multi-step computations.

The compilation of each student's work was reviewed and coded as "improved" or "not improved" for complexity and clarity. Improved clarity meant students progressed from poor to satisfactory or excellent, or from satisfactory to excellent in terms of their problem-solving strategies or calculations. Students whose work was categorized as "not improved" either began with clear and comprehensive writing, or their explanations never evolved. Students whose work improved in complexity went from completing no computations or very basic computations to satisfactory or excellent, or from satisfactory to excellent.

Standardized test scores and analysis. The MAP® test was administered at three points in time during the school year (fall, winter and spring). The test included five sections (number sense, measurement, algebra, geometry, and data analysis), each with its own score as well as an overall mathematics score. Results of the test are reported in Rausch Unit (RIT) scores. RIT scores indicate the level of difficulty at which a student answers questions correctly 50% of the time. The RIT scale is an interval scale and is independent of grade level or age.

The study design called for a one-way repeated-measures analysis of variance (ANOVA) to examine the changes in MAP® scores for the three administrations. A repeated-measures ANOVA was conducted for each of the math sections of the MAP® test, as well as the overall math score to identify statistically significant improvements in the mean test score of the class from the fall to the winter, winter to spring, and fall to spring test administrations.

Researcher initiated whole class discussion. The first author initiated an impromptu whole class discussion at the end of the year to discuss students' experiences with and feelings about, the MIEL. The discussion was recorded and transcribed. Student utterances were coded and categorized in ways organic to the content.

Results

Descriptive Statistics for MAP® Scores

The means and standard deviations for the MAP® scores are presented in Table 1. Additionally, twelve students (71%) improved their overall math score from the fall to winter, 14 students (82%) improved their overall math score from the winter to spring, and 13 students (76%) improved their overall math score from the fall to spring administration.

Table 1
Means and Standard Deviations for MAP Test Scores by Section

	Fall		Winter		Spring	
Test Section	*M*	SD	*M*	SD	*M*	SD
Number Sense	220.63	16.18	227.74	15.39	235.20	16.63
Measurement	225.78	13.65	227.44	13.01	236.53	14.30
Algebra	225.53	15.49	230.38	11.14	234.47	17.01
Geometry	230.69	12.41	228.68	14.52	244.57	15.92
Data Analysis	222.09	17.17	230.76	14.43	238.93	14.32
Overall	224.75	13.45	228.94	11.92	237.80	14.27

MAP® Scores Repeated-measure ANOVAs

One-way repeated-measures ANOVAs were conducted using the general linear model (GLM) approach for each of the five sections in the MAP® as well as the overall mathematics score. All assumptions were satisfied for the analyses, including sphericity, as all Mauchly's W values were non-significant at $p < .05$. The overall ANOVAs showed significant differences between the three time points for Number Sense $F(2, 26) = 5.87$, $p < .05$, Measurement $F(2, 26) = 8.63$, $p < .05$, Algebra $F(2, 26) = 3.54$, $p < .05$, Geometry $F(2, 26) = 22.79$, $p < .05$, Data Analysis $F(2, 26) = 9.89$, $p < .05$, and the overall math score $F(2, 26) = 19.76$, $p < .05$. Post-hoc pairwise comparisons using a Bonferroni correction were conducted following each significant ANOVA (see Table 2). Despite the significant overall ANOVA for the Algebra section, the pairwise comparisons revealed no significant differences between any of the time points. All other sections showed statistically significant improvements from fall to spring. The Measurement, Geometry, and overall math score also showed statistically significant improvements from winter to spring. None of the sections showed statistically significant improvements from fall to winter.

Whole Class Discussion Outcomes

Students' utterances fell primarily into three categories: 1) those related to their overall feelings about the MIEL; 2) those related to how the MIEL influenced their recent standardized test-taking experiences; and 3) those related to the MIEL as extra homework. Tables 3 through 5 show representative comments students made within each category.

Students' overall feelings about the MIEL focused on how the assignment opened their eyes to the mathematics they do outside of school and how it made the mathematics they did in school easier and more meaningful. Two themes emerged regarding the impact the MIEL had on test-taking. The first had to do with how well-prepared students felt for the unpredictable nature of test questions and the reduced anxiety that typically surrounds that unpredictability. The second had to do with the improved confidence and competence students felt with respect to extended response questions. Finally, despite it being extra homework the other fifth-grade classes did not have, most students saw the MIEL as giving them an advantage over their peers when it came to class work, testing, and succeeding with mathematics-related tasks and opportunities outside of school.

Table 2
Mean Differences and Significance Tests for the Mean MAP Scores for the Class

	Fall to Winter	Winter to Spring	Fall to Spring
Number Sense	5.96	5.96	11.93*
Measurement	1.21	7.86**	9.07*
Algebra	3.57	3.61	7.18
Geometry	-4.39	16.75**	12.36**
Data Analysis	6.89	9.18	16.07**
Overall	2.86	8.57**	11.43**

Note: $*p < .05$, $**p < .01$. A Bonferroni adjustment was made to alpha level for the pairwise comparisons. Mean differences were computed by subtracting the earlier time point from the later time point, resulting in the number of test score points improved between the two administrations.

MIEL Improvements

Of the 17 students in the class, 12 (71%) improved in their clarity of explanations from the fall term to the spring term. With respect to the complexity of explanations, 11 of the 17 students (65%) showed improvement from the fall term to the spring term. Figures 1 and 2 show examples of students' work that improved in complexity and clarity, respectively, over the school year.

Discussion

Preparing children for tests is a central part of most modern-day middle level mathematics programs. Teachers must find ways of preparing students beyond "teaching to the test" if they are going to be able to apply their learning to unfamiliar problems and circumstances and respond to the demands of test-taking. The MIEL discussed here is one possible approach to this. The assignment draws on what we have learned from decades' worth of literature supporting the practice of connecting students' out-of-school experiences with school-based curriculum and instruction.

A pivotal outcome of the MIEL relates to children's increased motivation for learning and doing mathematics. To motivate children, they need to identify with curriculum and feel like their life experiences not only matter, but also represent authentic purposes for engaging with mathematics (Brown, Bransford & Cocking, 1998; Ebby, 2011; Gutstein, 2002; McNair, 2000). When learners are motivated, they are more likely to sustain interest in a task (Csikszentmihalyi, 1990) and get more out of it (Shernoff, Csikszentmihalyi, Schneider and Shernoff, 2003). The MIEL offered students the opportunity to place themselves at the center of the mathematics involved in this assignment and to experience purpose and authenticity to problem solving.

Moreover, when the application of mathematical skills and problem solving strategies helps students make sense of their world and their agency in it, students are more likely to experience success (Newmann, Wehlage, & Lamborn, 1992; Weinberg, Basile, & Albright, 2011). Indeed, research shows a positive correlation between students' confidence and their test scores (Smith, 2002), and by students' own accounts, the MIEL prepared them for test-taking. The children spoke of their personal insights into the impact the assignment had on their confidence going into, and following, their most recent battery of standardized tests. They felt more prepared for novel problems and felt more confident that their personal approaches to problem solving were valid.

As we considered our results, we thought about the role testing might play in motivating students to continue learning mathematics and applying it to their everyday lives. Testing should have a purpose for students just as curriculum should. That is, students should feel like tests measure their progress toward and readiness for solving authentic problems that matter in their lives. Further, students should feel motivated by questions that challenge their current understandings and recognize that any deficits in their skills and problem solving strategies highlight areas for continued purposeful learning. Of course, teachers and administrators need to foster such a testing culture in ways that tie in to curriculum and instruction that also reflect purposeful, meaningful, and intentional learning.

In conclusion, it is unlikely that the MIEL assignment itself was the only factor contributing to students' test preparation and ultimately their improved test scores. Regular instruction aligned with district standards no doubt was also effective. However, the MIEL provided a regular and meaningful venue for students to apply and to practice their mathematics, as well as their problem solving and communication skills. We suggest that the assignment, and those like it, be considered as part of not only the curricular and instructional climate of a classroom, but also of a purposeful and meaningful test-taking culture that students can actively engage with and find agency therein.

Table 3
Students' Responses to What They Thought of the MIEL

Student	Sample Students' Responses
AC	It makes math easier because we are dealing with it more often.
AH	It is making us better [at math] because it takes what we learn in the classroom and apply it to everyday life.
SB	It made math easier because we are more aware now that we are doing math in our everyday life and more aware that we do math everyday.
JG	It makes math easier because it makes you look at your everyday life and shows you that math is useful.
GN	If we didn't have [the assignment] we wouldn't notice that we have math everyday in our life. I like trying to tie mine into the math lessons we do in class.
KK	It is just like reading, everywhere you go you do math.
GN	Our everyday math problems are not made up experiences that everyone has to work with. Everyday Math is good because it is your own experiences that you are writing about.
AH	You really get to get deeper into math. When you do it outside of school, you are saying that 'hey, this actually matters.' It is something you will use throughout your life.

Table 4
Students' Responses to the MIEL and Test-Taking

Student	Sample Students' Responses
JR	It prepared me for stuff because you don't know what math you're going to write about every week. There's unpredictability, like test questions, you don't what they're going to ask.
KK	We all [learn] math from the [book], yet we all encounter math problems in a different way. I know I can do a problem how I see it.
AC	It helped me with the math extended responses because for everyday math you have to write the steps that you take to solve the problem.
SB	At first, we wrote a few sentences [to describe our everyday math]. Now we are writing a longer answer.
KK	It really helped me in the math extended response on the ISAT.
SR	We don't just do math in school, but we also do math outside of school. Since we do math outside of school, we have more confidence when we are in school taking tests.

Table 5
Students' Responses to Having the MIEL as Extra Homework

Student	Sample Students' Responses
AC	It was better for us and gave us an advantage because we know more and use math more instead of just doing it for an hour every day.
JR	I don't feel lucky to have extra homework, but on a math test or on the long-run, it makes you feel lucky.
JG	Not always the most fun but it does put you at an advantage because it gets you thinking more about math…and you don't just forget math exists when you leave the classroom.

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