Outcomes Beyond Success in a Problem Centered Developmental Mathematics Class

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Low success rates in the pre-college level, or developmental, curriculum at many community colleges has resulted in the creation of classes that use problem solving and group work to help students become more mathematically empowered. This preliminary report describes one such class at a Midwestern community college and then outlines the results from a pre- and post-survey of students taking the class, focusing on whether students' attitudes towards mathematics changed while enrolled in the class. Further analysis will examine how students evaluated the class and ranked the class structures. Generally, males, younger students, and Black students were less likely to complete the course. Students who came close to completing the class had an overall positive shift in their attitudes towards mathematics.

Keywords: developmental mathematics, community college, problem solving, attitudes

Each year over 1 million students invest substantial time and money to take pre-college level classes that do not count towards a degree (Parsad, Lewis & Greene, 2003). Often called "developmental," such classes provide *all* students with the chance to be *college ready* (McCabe, 2000). However, as many as 67% of students who start developmental classes do not finish (Bailey, Jeong & Cho, 2010), which is particularly concerning given that developmental students disproportionately come from minority and low socio-economic backgrounds (Attewell, Lavin, Domina, & Levey, 2006). Despite the volume of students in developmental programs, research has rarely examined individual classes and students. Given this, an acute need exists for research on developmental math that looks beyond success rates (Mesa, Wladis & Watkins, 2014).

Developmental math tends to be taught using lecture with an emphasis on procedural knowledge (Grubb et al., 1999; Mesa, Celis, & Lande, 2014). The low success rates, combined with the fact that community college students have high levels of math anxiety (Sprute & Beilock, 2016) and appreciate knowing how what they learn relates to their lives (Cox, 2009), suggests that the traditional ways of teaching developmental math do not provide sufficient opportunities for students to change their opinions about mathematics or themselves as doers of mathematics. This study examines the outcomes beyond success of one developmental math implementation that attempts to better meet the needs of the developmental population.

Mathematical Literacy: Streamlining the Curriculum

Low success rates in developmental mathematics has led community college educators to create curriculum pathways that accelerate students through their required pre-college-level course work while promoting more real world connections. *Mathematical Literacy* at Fields Community College (FCC; all names are pseudonyms) is one such initiative. Rather than learning through lecture, students engage in group work. The teacher primarily acts as a facilitator while the students work on real world problems. The course is designed to be completed in one semester, which fulfills the students' developmental needs in a shorter time frame than the traditional algebra sequence.

The *Mathematical Literacy* movement is fairly new, but early results from national initiatives suggest students are more successful than students taught in traditional classrooms (Strother & Sowers, 2014; Yamada, 2014). Less understood is how students' relationship to math changes after taking classes like this and students' experiences in these classes. Developmental classes offer one of the last opportunities for students to explore mathematics and challenge their ideas about math, so it is important to investigate whether and how students' attitudes towards math change in these new developmental classes. In particular, I investigate:

- Who finishes *Mathematical Literacy* at FCC?
- Do the attitudes of students who finish *Mathematical Literacy* change during the course of the semester? How do attitudes vary between students with different characteristics?
- Is there a relationship between the magnitude of students' attitudes towards mathematics and their background characteristics?
- How are students' evaluations of the class related to their attitudes towards mathematics?

Methods

Sample

In total, 150 *Mathematical Literacy* students from eight surveyed sections at FCC participated. All FCC *Mathematical Literacy* instructors were invited to participate. Sections were surveyed in all instances when the instructor agreed to participate. Three sections occurred in the in fall (n = 53) and five sections in the spring (n = 97). The number of students participating from a particular section ranged from 15 to 24 students.

Data Sources

Data for this study come from a pre- and post-survey given to students during the first and last week of the semester, respectively. Both the pre- and post-survey included the Attitudes Toward Mathematics Inventory (ATMI; Tapia & Marsh, 2004) to measure mathematics attitudes along four dimensions related to mathematics performance: enjoyment of mathematics (8 items), motivation (9 items), self-confidence (15 items), and value (8 items). Students answered items using a 5 point Likert scale on items. The pre- and post-surveys also include single item questions asking about the nature of mathematics (i.e., "learning math is mostly memorizing facts") and about students' level of comfort with certain types of class structures (i.e., "I learn mathematics best when I get to work in a group"). In addition, both surveys contained free-response items asking about students' mathematical backgrounds (pre-survey), demographics (pre-survey), educational plans (pre-survey), expected grades (post-survey), and course evaluation (post-survey).

Analytic Methods

To determine who completes *Mathematical Literacy* I ran descriptive statistics on the pre-survey sample and compared these to the descriptive statistics of the post-survey sample.

To examine whether or not the attitudes of students' towards mathematics changed over the semester, I conducted a confirmatory factor analysis on the ATMI scales. For brevity, in this proposal I report only the results from the original scales. Analysis using the attitude scales were run on both the original scale and the scales created after the confirmatory factor analysis. The general trends of the findings discussed in the results section are the same for both sets of scales.

Using the attitude scales, I performed paired sample t-tests to determine whether attitudes of those who come close to completing the class changed significantly over the 16 week class. To test for differences in attitudes growth between different sub-populations, I ran independent sample t-tests between different sub-populations of interest.

To examine the relationship between the changes in attitudes and students' background characteristics, I performed two-level Hierarchical Linear Models (HLM) with teachers as a level-two variable and students as level one. Separate models were run for each of the four attitudes, with the post-survey attitude scores as the dependent variable. Independent variables were students' pre-survey attitude score, gender, race, age, anticipated grade, whether or not they had taken previous developmental math classes, and the highest degree they intended to earn.

I will use descriptive statistics, basic qualitative coding, and HLM modeling to examine the attitude scales and class evaluation data and their relationship to students' backgrounds.

Results

Who Completes Mathematical Literacy

Although eight sections took the pre-survey, one class section did not take the post-survey because the survey schedule did not work out for the instructor. Within the students who had the opportunity to take both the pre- and post-survey resulted in a 63.3% retention rate between the pre- and post-survey. Students in this group who did not take the post-survey were, for the most part, no longer actively pursuing the course for personal or academic reasons. All of the students who took the post-survey reported that they expected to pass the class.

Descriptive statistics for participants who took only the pre-survey, compared to those who took both surveys are summarized in Table 1. Notably, the whole survey sample is more female than male and majority white, which is consistent with the developmental population at FCC. Those who only took the pre-survey were more likely to be male, more likely to be Black, and were a couple years younger than the students who took both surveys.

Table 1. Demographics of Survey Samples

	Whole sample		Pre-survey only		Took both surveys	
	n	%	*n*	%	*n*	%
Gender						
Male	65	45.14	34	52.31	31	47.69
Female	79	54.86	27	34.18	52	65.82
Race						
White	52	56.52	8	15.38	44	84.62
Black	29	31.52	21	72.41	8	27.59
Hispanic	5	5.43	1	20.00	4	80.00
Asian	5	5.43	0	0.00	5	100.00
Other	1	1.09	0	0.00	1	100.00
Taken prior developmental	93	35.86	44	47.31	49	52.69
No prior developmental	52	64.14	21	40.38	31	59.62
Age (years)	150	22.71 (7.88)	69	21.59 (7.31)	81	23.66 (8.26)

Note: Age reports the mean age of the participants in years followed by the sample standard deviation.

Changing Student Attitudes in *Mathematical Literacy*

Students who took both surveys had average positive gains on all four of the measured attitudes towards math. The shift in their enjoyment of math was significant. Students who were enrolled in their first developmental class had an overall positive increase in their value of mathematics, compared to those who had taken previous developmental math (Table 2).

Students were significantly more likely to disagree with the statement "there is only one way to solve a mathematics problem" at the end of the semester than they were at the beginning of the semester (Table 3). On other nature of math items there were no significant differences. They were also likely to shift whether or not they thought they learned mathematics best in a group or not, but these results were not significant. The high mean pre-post difference combined with the high standard deviation for these items ($\overline{x}$ = -0.185, *sd* = 1.246) suggests, however, that students were changing their mind about whether they agreed with these statements or not.

Table 2. Attitude Change Results for Selected Sub-populations

	Comparison of pre-post-survey attitude scores (complete data on both surveys)				Average growth in attitude scores of those with no prior developmental math compared to those that did				
					N		Pre-post difference		
Attitude	*N*	Pre-score	Post-score	*t*-stat	No prior devel. math	Prior devel. math	No prior devel. math	Prior devel. math	*t*-stat
Confidence	61	2.859	2.986	1.562	36	23	0.174	0.064	0.638
Enjoyment	74	2.941	3.093	2.406*	44	28	0.202	0.076	0.943
Motivation	73	2.830	2.925	1.637	44	27	0.073	0.136	-0.502
Value	68	3.756	3.813	1.064	40	26	0.144	-0.082	2.047*

*$p<0.05$

Note: Attitude scores were scaled to be on a 5 point scale with 1 corresponding to "Strongly agree" and 5 corresponding to "Strongly disagree."

Table 3. Attitudes Shifts towards Math and Classroom Structures

Item statement	N	Mean post-pre difference	Standard deviation
Learning mathematics is mostly memorizing facts.	77	-0.039	1.032
There is only one way to solve a mathematics problem.	80	-0.288*	1.171
I enjoy working in small groups in math class.	78	-0.077	1.066
I learn mathematics best when I get to work in a group.	81	-0.185	1.246
I learn mathematics best when I work by myself.	81	0.185	1.205
The math I learn in school rarely helps me when I use math in my daily life.	78	-0.115	1.032

*$p<0.05$

Note: Items were scored on a 5 point Likert scale, with 1 corresponding to "Strongly agree" and 5 corresponding to "Strongly disagree."

The Relationship between Attitude Change and Background Characteristics

For each of the measured attitudes, the biggest significant predictor of how attitudes changed was their pre-survey attitude score. However, intending to earn a Masters or higher significantly predicted an increase in the value of mathematics. Expecting to earn a grade of A in the class significantly predicted an increase in their mathematical confidence. The full results of the HLMs using the original scales on the ATMI are presented in Table 4.

Discussion & Conclusions

The results presented in the previous section highlight many positive outcomes beyond success rates in a *Mathematical Literacy* classroom. A 63% retention rate may seem low, but this number is higher than many developmental math instructors experience when teaching using traditional methods. That the students who completed the class experienced an average positive growth in their attitudes towards and views of mathematics also warrants excitement. Although only enjoyment showed a significant increase, several others were close to being significant. A larger sample could produce more robust results. Given that community college students do

Table 4. HLM Coefficients for Models Predicting Post-survey Attitude Scores

	Value	Confidence	Enjoyment	Motivation
Fixed effects				
Pre-attitude score	0.692***	0.560***	0.647***	0.738***
	(0.085)	(0.090)	(0.088)	(0.089)
Male	0.081	-0.040	0.169	0.179
	(0.099)	(0.150)	(0.129)	(0.124)
Race/Ethnicity				
Black	-0.020	-0.218	0.138	0.086
	(0.159)	(0.230)	(0.198)	(0.204)
Hispanic	-0.012	-0.404	0.029	0.095
	(0.235)	(0.363)	(0.294)	(0.310)
Asian	0.436*	-0.519+	0.118	-0.078
	(0.198)	(0.311)	(0.244)	(0.230)
Other	0.464	0.478	0.475	0.000
	(0.382)	(0.542)	(0.512)	(.)
Age (years)	-0.003	-0.001	0.009	0.005
	(0.006)	(0.010)	(0.009)	(0.008)
Prior developmental	-0.180+	0.047	-0.170	0.042
	(0.104)	(0.156)	(0.134)	(0.131)
Expected grade				
A	0.110	0.606**	0.319*	0.231
	(0.123)	(0.190)	(0.159)	(0.158)
B	0.076	0.367*	0.069	-0.052
	(0.108)	(0.157)	(0.136)	(0.133)
Anticipated degree				
Bachelors	0.023	-0.026	-0.070	-0.023
	(0.127)	(0.204)	(0.170)	(0.164)
Masters or higher	0.364**	0.166	-0.010	0.190
	(0.138)	(0.229)	(0.183)	(0.183)
Unknown	0.174	0.322	0.519	0.401
	(0.373)	(0.386)	(0.366)	(0.350)
Constant	1.046**	1.092***	1.070***	0.667*
	(0.335)	(0.300)	(0.297)	(0.302)
Random Effects				
Teacher	0.000**	0.000**	0.000*	0.040
Residual	0.338***	0.477***	0.464***	0.442***
Sample size	65	58	71	69

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

experience a lot of mathematics anxiety, these results are certainly worth investigating further to determine which parts of *Mathematical Literacy* contribute to the students' shift in attitudes.

That said, some results suggest that *Mathematical Literacy* does not reach everyone equally. The overall rate of persistence in *Mathematical Literacy* is higher than for traditional classes, but the students who did not complete the class were more likely to be Black and male than the students who did. Community college mathematics classrooms are an important and under-examined area in mathematics education. Given that Black students disproportionally enroll in developmental math, understanding the issues that keep these students from succeeding in *Mathematical Literacy* deserves a closer look.

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