Developmental Mathematics Success: Impact of Students' Knowledge and Attitudes

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> *Initial success in mathematics has the potential to provide students with "early momentum," that would contribute to their overall success in college.*

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***Abstract:* In order to improve student success within developmental programs, we conducted a study of 1st year students taking required, developmental mathematics courses at a large, urban public university. Findings suggest that merely the number of years of mathematics that students take in high school is not a precise indicator of student readiness and that passing courses in high school does not necessarily imply that students are prepared for the level of rigor expected in postsecondary institutions. Furthermore, results advocate for the re-evaluation of developmental mathematics courses to include student outcomes that focus on attitudes about mathematics in addition to content and skills.**

In recent years, much attention has been focused on students taking developmental courses (Bonham & Boylan, 2012; Rosin, 2012). Statistics indicate that almost 60% of students who enroll in community colleges must take developmental mathematics before they are eligible to enter college-level coursework (Bailey, 2009; Schwartz, 2007). Additionally, in the California State University (CSU System) in 2008, approximately 56% of all entering freshmen required remediation in mathematics and/or English (Johnson, 2010); in 2011, over 30% of first-time freshmen needed to do so specifically in mathematics (California State University System, 2012). In a study done in Nevada in 2006/7, more than one-third (37.6%) of students entering a two- or four-year institution of higher education required remediation in mathematics (Fong, Huang, & Goel, 2008). Furthermore, 80% of 1st-year college students taking a developmental course at public, four-year institutions in 2000 needed to do so in mathematics (Duranczyk & Higbee, 2006).

Students are typically placed into required developmental programs by their performance on high-stakes placement exams (Bailey, 2009). Although intended to help support student success in mathematics, remediation can have negative consequences for students, and in some cases can become a barrier for future academic achievement (Noel-Levitz & CAEL, 2006). Initial success in mathematics has the potential to provide students with "early momentum," that can contribute to their overall success in college. Conversely, lack of success can discourage them from completing their studies (Rosin, 2012). These students have a longer road to completing mathematics requirements, and many give up before they finish the sequence of courses. Additionally, many students are not successful within these courses; only 30% of students at two-year colleges pass all of the developmental mathematics courses in which they enroll (Attewell, Lavin, Domina, & Levey, 2006), and students who need remediation are less likely to complete a degree (Bailey, 2009). Furthermore, taking developmental courses the entire first year is costly, as well as delays graduation for those needing mathematics courses. Time for remediation can also dissuade students from seeking majors that require mathematics.

Why are so many students requiring remediation, and why are some unable to successfully complete it? In order to improve student success within developmental mathematics programs, we need a detailed picture of who these students are, both in terms of their mathematical preparation and affect. For example, do they possess essential skills and attitudes needed to be successful in such courses? Students' negative attitudes and anxiety toward mathematics must be overtly addressed in order to support their academic success and likelihood for pursuing mathematical coursework (Tobias, 1993). Little research exists that explores student traits in developmental courses. We also need to examine how, if at all, their experiences in developmental mathematics courses are enhancing their overall content understandings, skills, and attitudes toward learning mathematics. To this end, the following research questions guided our study of 1st-year students taking required, developmental mathematics courses at a large, urban public university:

1. What are the common characteristics of students taking developmental mathematics courses in terms of their previous mathematics coursework, perceptions of mathematical ability and confidence, and

attitudes towards learning mathematics both generally and in their current developmental course?

2. In what ways do students' perceptions of their skill, confidence, and attitudes appear to change after taking a developmental mathematics course, and what factors appear to be affecting those changes?

Review of Relevant Literature

Within the research on developmental mathematics courses, two essential areas are highlighted as important to students' success: (a) a strong alignment between college curriculum (as measured by mathematics placement tests) and high school mathematics curriculum and assessments and (b) positive student affect relative to mathematics (Brown & Niemi, 2007; Gamoran, Porter, Smithson, & White, 1997; Hill, 2008; Willett, Hayward, & Dahlstrom, 2008).

Curricular Alignment

Secondary course work is expected to prepare students for postsecondary education. In particular, classes such as calculus, mathematical analysis, and other advanced courses are intended to prepare students for advanced postsecondary study and place them beyond remediation in college. Unfortunately, literature suggests that many graduating seniors are leaving high school without acceptable college-level content knowledge (Cambell & Blakey, 1996).

One critical reason why the nation's high schools are not adequately preparing students for the demand of college is weak curricula; high school content must be aligned with the expectations of college and university-level courses, which is evidently higher than the minimum requirements for graduation (Kraman, D'Amico, & Williams, 2006). Over the past few decades there has been much attention on establishing frameworks for alignment (Anderson, 2002). Most recently, emphasis has been on the distinction between *horizontal alignment* and *vertical alignment* (Case & Zucker, 2005). Horizontal alignment focuses on the alignment among content standards, instruction, and assessments within a given grade level or course; vertical alignment concerns alignment of all aspects of curriculum across an entire education system (Case & Zucker, 2005). It is not enough for educators to examine only one point in a students' academic program; all aspects must be considered together, and alignment across a students' entire mathematics education is essential.

There have been recent endeavors to tighten the connection between high school and college curricula. In 2006, then President Bush allocated funds to increase advanced high school courses offered. Aiming at building a focused and coherent mathematics curriculum system across the United States and fully preparing high school graduates for college and career, the Common Core State Standards for Mathematics (CCSSM; National Governors Association, 2010) have gained unprecedentedly wide support in the past 3 years. By the end of 2011, 45 states and 3 U.S. territories had officially adopted the CCSSM as the core of their future mathematics standards (National Governors Association, 2010). Even more recently President Obama launched the "Make College A Reality" initiative, which will increase student enrollment in college-level courses 50% by 2016 (Long, Conger, & Iatarola, 2012). Academia-motivated efforts include bridge and pathway programs that facilitate relationships with partner community colleges. One main focus of such programs is on remedial courses, specifically connecting learning outcome discrepancies within these courses in order to improve college-level placement.

Auspiciously, students taking advanced courses in high school have a higher graduation rate (88%) than those who only complete the minimum requirement of Algebra I (62%). In particular, students who take an advanced level mathematics course early in their high school years boost their overall likelihood to attend college by 10% to 15% and also appear to shift enrollment from 2-year to a 4-year university (Long, Conger, & Iatarola, 2012). However, a substantial number of students are not taking the necessary mathematics coursework to attend universities. For example, data released by California Department of Education show that between 1996 and 2007 only about 29% to 34% of high school graduates successfully completed course requirements necessary for the state's two largest public university systems: University of California and California State University (Johnson, 2010). Furthermore, 25% of students that do graduate complete their coursework below standard (Nord et al., 2011). Additionally, according to a recent California basic skills accountability report, approximately 85% of students assessed for mathematics placement do not place beyond Intermediate Algebra (Rosin, 2012).

> *Aligning curricula involves increasing the rigor of high school curricula.*

Although some students are successfully passing high school mathematics courses and are attending postsecondary institutions, they are clearly not ready for success within mathematics at a level comparable to when they leave high school; many of these students arrive at college inadequately prepared. National and regional studies indicate that approximately 20-33% of freshmen enroll in a developmental mathematics course during their first year of study at four-year universities (e.g., Adams, 2013; Fong, Huang, & Goel, 2008). Although students can attempt and successfully pass courses already completed in high school, retaking such classes may have detrimental cost and effects. Additional courses use up valuable time, prolong degree completion, and may be costly to the student and the state. Students who need remediation are less likely to complete a degree; specifically, only 52% of remedial students attending four-year universities (as compared to 78% of students without remedial coursework) and 28% of those attending two-year colleges (as compared to 43% of nonremedial students) graduate (Bailey, 2009; Institute of Education Sciences, 1988).

Unfortunately, not all courses required to pass high school are challenging and in-depth enough to prepare students for the academic rigor expected at college (Creech, 1997). For example, to fulfill mathematics requirements students typically need to complete Algebra I, or the equivalent. However, colleges expect students to complete at least two courses beyond that and maintain a fundamental conceptual understanding. Thus, aligning curricula involves increasing the rigor of high school curricula, which is a strong predictor of college readiness (Adelman, 2006; Gamoran, Porter, Smithson, & White, 1997). Furthermore, the rigor must entail thorough content exposure within those courses with a high level of cognitive demand; both the procedural conceptual understandings of students must be considered (Anderson, 2002). For example, a study for the Nevada public colleges and universities reported that students who did well in a less rigorous course were less likely to require remediation, as compared with students who took the next level of mathematics but performed poorly. For example, students who took an Advanced I course (Algebra/Trigonometry) with an overall grade of "A" were less likely to require a remedial mathematics course compared to students who took an Advanced II course (Pre Calculus) with an overall grade of "C," 18% compared to 24% (Fong, Huang, & Goel, 2008).

In order to shed light on alignment between secondary and college-level curricular demands, we examined the background of students required to enroll in developmental mathematics courses (e.g., secondary math courses passed, perceptions of preparedness and skill level) as well as how well they performed within these courses. Understanding who these students are both as they enter and complete developmental mathematics courses is essential to improving potential for their success, as well as pathways connecting secondary and college-level curricula.

Affective Components

Student self-perception, confidence, attitudes and beliefs, and anxiety are all linked to persistence and motivation to study mathematics. Additionally, students with positive attitudes will be more motivated to think mathematically, understand class content, and dedicate extra effort towards the course than students who possess negative attitudes toward the content (Kargar, Tarmizi & Bayat, 2010). An essential objective of mathematics education has been to develop students' willingness to tackle and confidence in challenging mathematics as well as positive dispositions toward the subject and learning of that subject (National Council of Teachers of Mathematics, 2000). These factors embody a student's *mathematics identity* (Bishop, 2012), which can have a powerful impact on his or her learning and achievement (Ma & Kishor, 1997).

Disappointingly, as expressed earlier in this paper, only 30% of community college students pass the required developmental mathematics sequence in which they enroll (Attewell, Lavin, Domina, & Levey, 2006). What makes completion especially challenging is that students often come to mathematics courses with a high degree of anxiety, frequently rooted in earlier failures (Rosin, 2012). Mathematics anxiety is "a feeling of tension, apprehension, or fear that interferes with math performance" (Ashcraft, 2002, p. 181). There is a significant relationship among mathematical thinking/performance, anxiety, and attitudes towards mathematics (Ho et al., 2000). For example, the results of a meta-analysis of previous research studies conducted by Hembree (1990) show that math anxiety relates inversely to positive attitudes towards mathematics and is bound directly to avoidance of mathematics. Furthermore, students who have high math anxiety have low mathematical thinking and attitude (Ma & Kishor, 1997). One theory suggests that math anxiety taxes and competes with resources that are normally used for working memory, and an increasingly taxed working memory leads to greater mathematical error and worse performance. This is especially true as math tasks become more complex and require increased levels of working memory (Ashcraft, 2002). Students' negative attitudes and anxiety toward mathematics must be overtly addressed in order to support their academic success and likelihood for pursuing mathematical coursework (Tobias, 1993).

Although affective factors have proven to be relevant to mathematics learning in general, the affective domain is often left out in efforts to increase students' performance in developmental mathematics. As a result, students who must take developmental mathematics courses are not necessarily developing positive math identities. Additionally, the necessary time and cost needed for remediation often dissuades students from seeking majors that require mathematics (Rosin, 2012). Researchers have emphasized that "this is a rich area of information for educators designing developmental mathematics courses and one that should definitely not be ignored by anyone attempting to improve student performance in developmental mathematics" (Bonham & Boylan, 2012, p. 16). Specifically, more needs to be known about students' perceptions of their unsuccessful and successful learning in developmental mathematics, including the affective factors that would help to enable positive shifts in students' learning experiences (Howard & Whitaker, 2011). For example, motivation is a commonly recognized factor that distinguishes between students' unsuccessful and successful learning experiences in developmental mathematics (Howard & Whitaker, 2011).

In order to better understand how developmental programs can support students to develop positive mathematical identities, in this study we carefully examined students' attitudes toward mathematics and learning mathematics. We also studied the effect that their experiences in developmental mathematics courses had on their attitudes, beliefs, and motivation.

One theory suggests that math anxiety taxes and competes with resources that are normally used for working memory.

Methodology

Participants and Context

Primary participants were students ($N = 376$) in a semester-long section of the midlevel developmental mathematics courses (Intermediate Algebra) at a large, urban state university (California State University, Long Beach–CSULB); participation was voluntary, and students were informed that instructors would not see survey responses. At CSULB students are allowed one academic year to complete remediation; although a small percentage (8-10%) of students had completed this course during a special summer session, most students needing Intermediate Algebra took it during the fall semester.

Data Sources

Data were collected during Fall 2008. There were 11 sections and 6 instructors (some instructors taught multiple sections). Primary data sources included: anonymous student pre-post surveys (administered in first and final classes of the course; $N = 376$ for pre, and $N = 306$ for post); an e-mail administered survey for course instructors (67% response rate); and, artifacts related to the mathematics department and institutional data relative to remedial mathematics at CSULB (e.g., passing rates, course grades). Student surveys contained both open-ended and Likert-type questions, 1-6 scale (Benken & Brown, 2008). They asked about participants' expectations for and experiences within the developmental mathematics course; their anxiety, attitudes, and confidence related to mathematics and mathematics learning; their level of skill preparation (pre- and postcourse); and their impressions of the course and instructor. The number of students completing the postsurvey was smaller than the presurvey due to many factors, including students dropping the course and/or being absent the day it was administered.

Instructor surveys included only open-ended questions regarding their experiences teaching developmental courses, observations of their students' learning and needs, and recommendations for the mathematics department and future iterations of all courses they had taught. All instructors teaching Intermediate Algebra were encouraged to complete the survey.

Analysis

A quantitative method was used to analyze quantifiable portions of pre- and postsurveys. Data analyses were in the form of descriptive statistics (Creswell, 2009), for example, means and standard deviations, linear regression, z-tests, and t-tests (unpaired, 1-tailed and 2-tailed). Some items were compared both within surveys and across surveys to identify correlations and trends, as well as to support qualitative themes.

A qualitative method was used to analyze participant responses on non-Likert/quantifiable items (e.g., How confident are you that you will pass this class?). When appropriate, some item responses were coded based on level of emphasis and frequency and then subdivided for further analysis, much of which was quantitative in nature. For example, for the aforementioned question, responses were coded (yes, somewhat, unsure, no) and then compared to multiple items (e.g., perception of ability). As another example, participants' comments relative to number of hours they had studied outside of class were coded (0, 1-3, 3-5, more than 5) and then quantitatively compared to passing rate and confidence items.

Validity issues were addressed by cross-validation of results by a team of four researchers; all analyses were verified by at least two researchers, who conducted them either independently or collaboratively. Additionally, Likert-type survey questions were validated in a previous study (Benken & Brown, 2008). Reliability was addressed through similarly designed pre-post surveys, as well as through multiple approaches to inquiry of traits (e.g., confidence).

Results

We organize these findings by our research questions. Within each question, we present overarching themes that resulted from a synthesis of both qualitative and quantitative analyses.

Portrait of Students Entering Developmental Mathematics

We examined the following: What are the common characteristics of students taking developmental mathematics in terms of their previous mathematics coursework, perceptions of mathematical ability and confidence, and attitudes towards learning mathematics both generally and in their current developmental course? Students were similar in many ways; however, closer examination separating students by level of mathematics achieved while in high school revealed subtle yet important differences in how and the extent to which students changed.

Common characteristics. Students placed into developmental mathematics courses displayed some common traits and characteristics. First, most participants had taken more mathematics than was required for entrance to California State University (CSU) system. Specifically, almost 60% of participants had completed courses beyond Algebra II (e.g., Statistics, Trigonometry/Pre-Calculus, Calculus). Additionally, the majority (66%) of participants had taken mathematics all 4 years of high school. Although this finding contradicts most typical profiles of students who are placed in remedial mathematics, it is worth mentioning that the data also revealed that almost one-fourth (23%) of participants took 3 or 4 years to earn a passing mark in the minimum requirement (Algebra II).

Table 1

Presurvey Results of Self-Perception

Self-Perception	Question	Mean Rating	*SD*
Skills	When you applied to the CSU system, how would you rate your overall mathematics skills?	3.56*	0.77
Enjoyment	When you applied to the CSU system, how would you rate your enjoyment in mathematics?	2.84*	1.31
Confidence	When my answer to a math problem doesn't match someone else's, I usually assume my answer is wrong.	4.03**	1.45

Note. *1 = very weak, 6 = very strong; **1 = strongly disagree, 6 = strongly agree

Table 2

Student Profile by Highest Course Completed

Highest Course Completed	% of Participants in Group	% of Group that Took Math in 4th Yr	Mean Rating of Skill Level*
Group 1 (Algebra II)	41.0%	56.6%	3.35
Group 2 (Trig, Math Analysis, Pre-Calculus)	38.3%	69.0%	3.67
Group 3 (Stat, Calculus, A.P. Courses)	20.7%	85.2%	3.87

Note. * 1 = very weak, 6 = very strong

As Table 1 depicts, in general participants did not enjoy mathematics, yet they perceived their overall level of mathematical skill to be average. In fact, they almost always rated their perceived mathematics skills significantly higher than their enjoyment of mathematics. Despite testing into a developmental mathematics course, participants were fairly confident in their mathematical abilities. Additionally, a vast majority of participants (82%) were also confident that they would pass the developmental course regardless of the perceptions they held about mathematics.

Groups by highest course completed in high school (grades 9-12). Although similarities existed across all participants (e.g., success expectancy, continuous exposure to math), a significant difference in participants' self-perception of skill level was noticed when we categorized students into three groups based on the highest mathematics course passed in high school (see Table 2). The first group consisted of participants who only completed the minimum high school mathematics requirement for admission to their state university system; thus, they had all passed Algebra II with a "C" or better, yet had either not taken or had received a "D" or "F" in courses beyond Algebra II. Just over half of Group 1 participants took 4 years of mathematics in high school, suggesting that students in this category either took all 4 years to successfully reach and pass second year Algebra, or they took and did not pass a course beyond second-year Algebra with at least a "C." Considering participants in this group passed the least amount of coursework yet had a substantial amount of exposure to math in high school, it is not unexpected that their overall rating of skill level was neither high nor low but at a central point of 3.35 (scale 1-6). This group's self-rating of their skill level was lower than any other group.

The second group consisted of participants who had passed a course beyond Algebra II (e.g., Trigonometry, Math Analysis, Pre-Calculus) in high school. Participants in Group 2 represented 38.3% of all students in remedial math (see Table 2, p. 17); over two-thirds of them took a mathematics course all 4 years of high school. Participants in this group rated their skill level higher than those participants in Group 1; however, the difference is not statistically significant, and is just slightly above the mean for the entire set of participants.

The third group of participants consisted of those who had passed either Statistics or Calculus (including Advanced Placement) in high school; this group was the smallest of the three at about 21% of all participants (see Table 2, p. 17). These participants were also the most likely to have taken 4 years of mathematics in high school (over 85%). As would be expected, Group 3 participants rated their skill level the highest of the three groups, which was extremely statistically significantly higher than the students in Group 1.

Changes in Students Following Developmental Mathematics

Our second research question explored how participants' perceptions of content and attitude towards mathematics changed as a result of completing the course: In what ways do students' perceptions of their skill, confidence and attitudes appear to change after taking a developmental mathematics course and what factors appear to be affecting those changes?

Changes in select common characteristics. Overall, participants reported positive changes in their self-perceptions regarding mathematics. Specifically, participants reported a positive change in their perceived skills, enjoyment, confidence, and comfort related to mathematics (see Table 3). Of these four categories, participants felt that their skills increased the most. Comparing pre- and postsurvey responses, participants' mean skill level grew over half of a Likert point (extremely statistically significant, $p<.0001$).

Some specified they felt inaccurately placed considering they fell short placing out of remediation by only "a few" points.

Additionally, enjoyment of mathematics was also shown to rise (extremely statistically significant). Confidence was measured using self-perceptions of their own ability to derive the correct solution. This was also shown to increase about one-third of a Likert point. Average responses in the presurvey were higher than in the postsurvey, which represents a difference that is very statistically significant, indicating an increase in confidence. Participants were also asked if mathematics made them feel uncomfortable or nervous. The presurvey mean results were observed higher than that of the final postsurvey indicating a statistically significant decrease in uncomfortable levels. This perception differed the least, yet was still significant, suggesting that participants became more comfortable with and were less nervous about mathematics.

Although there was a positive change in participants' self-perceptions, the overall postmeans were still in the middle of ratings on the 6-point scale (3-4 considered neutral). Specifically, skills, enjoyment, confidence and comfort postratings were all between 3.19 and 4.14 (see Table 3).

Relationship among perceptions. Although participants' perceptions positively expanded in the four areas reflected in Table 3, there was no direct connection found across them. For example, enjoyment levels increased, yet post means were still lower than those for perceived skills. Furthermore, instructor surveys conveyed that the instructors also perceived their students (participants) to be insufficiently motivated to succeed. Therefore, it is not surprising that about 63% of participants reported studying three or fewer hours outside of class, and only about 5% reported studying the university required ratio of 1:3 hours of within class to outside class time.

Connection between perceptions and course completion. Despite the large increase in perceived skills (see Table 3), only 77.9% successfully passed this course ("C" or better) and thus completed remediation on this first attempt, with some sections having passing rates in the low 60% range. When asked during the first class meeting how certain they felt about passing the course, 82% of participants reported they would achieve a passing mark.

An overwhelming number of participants indicated on the postsurvey that they did not realize the high-stakes nature of the placement exam; they indicated that if they had refreshed/studied, they would have placed out of remedial mathematics. This finding further confirms that participants had high confidence and believed that they knew more than what their assessment test and course grades showed. Particularly, some specified they felt inaccurately placed considering they fell short placing out of remediation by only "a few" points.

Participants completing the developmental course viewed themselves as having improved skills with high confidence in passing the class. However, despite some improved perceptions and attitudes, their overall self-perceptions remained relatively average.

Retention of mathematical beliefs. Comparison of pre- postsurveys also suggests that this course did not have a large impact on participants' more general beliefs toward mathematics. For example, participants were asked if they felt certain individuals are naturally better at math. A comparison between pre- and postsurveys indicates that this result increased the most over any other question observed (see Table 4, p. 20). Thus, there

Table 3

Pre vs. Postsurvey Results of Student Self-Perceptions

Self-Perception	Question	Mean (*SD*) Pre	Mean (*SD*) Post	ΔMean	*p* value
Skills	How would you rate your overall mathematics skills?	3.56* (.77)	4.14* (.98)	0.583	$p < .0001$
Enjoyment	How would you rate your enjoyment in mathematics?	2.84* (1.31)	3.22* (1.48)	0.388	$p = .0004$
Confidence	When my answer to a math problem doesn't match someone else's, I usually assume my answer is wrong.	4.03** (1.45)	3.69** (1.43)	-0.339	$p = .0023$
Comfort	Mathematics makes me feel uncomfortable and nervous.	3.46** (1.56)	3.19** (1.36)	-0.264	$p = .0076$

*Note.**1 = very weak, 6 = very strong; **1 = strongly disagree, 6 = strongly agree was an extremely statistically significant increase in participants' belief that some people just have a knack for doing mathematics.

Changes were noted regarding another common mathematical belief: considering mathematics to be merely memorization of facts. Comparing pre- and postsurvey results relative to this belief, participants' means dropped (see Table 4, p. 20), revealing a very statistically significant change. Although they were less likely to think of math as memorization after the course, just as in the previous traits, final means still fell within the "neutral" range of the scale.

Disconnect between learning and remembering. After completion of the course many participants reported recalling material from high school rather than learning new content. Many expressed that if they were introduced to a concept then they automatically learned it. For example, when asked if, "As a result of the course do you feel you are better at math?" about 80% agreed; however, almost 35% related their perception of "better" to recalling previous information and not necessarily learning any new content. The answers to the question are you better at math fell into three main themes; participants who said no, participants who said yes but attributed it to recalling material previously learned, and those who said yes and related it to learning new content (see Table 5, p. 20). These results were then compared to participants' view of mathematics as vastly comprising memorization. Participants who reported learning new content were significantly less likely to perceive mathematics as memorizing procedures. Participants who viewed the course as a review that helped them recall material were more likely to view mathematics as memorization. Additionally, this latter group is the only one that fell above the overall average of 4.29. Interestingly, instructors conveyed their impression that most students viewed the course as a means to "review," rather than as an opportunity to learn new content. They attributed this view to students being overly confident in their level of

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skills, and attributed most failures in the course to students not realizing they did not sufficiently understand the content.

Students were also asked whether they felt their instructor was helpful. The responses were separated into nine reoccurring themes and a value of 0, 1, or 2 was assigned to each of these themes. The first theme was not helpful (value of "0"), the second theme was unsure (value of "1"), and the remaining themes fell under helpful (value of "2"). Helpful themes included positive atmosphere, availability of instructor, approachability, clarity, relatability, strong content knowledge, and other nonspecific helpfulness. Incorporating data regarding participant perception of whether a participant's instructor was helpful to their "better-ness" revealed a correlation among the three categories (see Table 5). Participants who did not feel better at math were least likely to think of their instructor as helpful, next followed those who were remembering content, and finally by participants who learned content; this final group rated their instructor as the most helpful of the three groups and is the only group that fell above the overall average of 1.79.

Discussion

A typical educational belief is that most students in developmental courses do not take math in the fourth year of high school; the literature suggests that any mathematics, as long as students remain in math for 4 years, is good for their long-term mathematical achievement (Zelkowski, 2010). However, results of our study show that number of years alone is not a precise indicator; almost two-thirds of participants requiring remediation had remained in mathematics for all 4 years of high school. Additionally, almost two-thirds had taken higher level math in high school than the developmental course in which they were placed, with over 20% having taken advanced courses (e.g., Calculus). We found it troubling that so many students with a history of extensive mathematics coursework required remediation. Passing courses in high school does not necessarily imply that students are ready for the level of rigor expected in postsecondary institutions. Our study suggests that we must reexamine what we intend by "ready." Specifically, does earning a grade of "C" truly indicate that students are able to be successful at the next level?

Almost two-thirds of participants requiring remediation had remained in mathematics for all 4 years of high school.

Students requiring remediation in our study initially held positive views of their level of knowledge and skill and were highly confident that they would be successful in their developmental courses; however, many held inaccurate conceptions, and most also indicated throughout remediation that they did not enjoy mathematics, even after half or an entire year. It is important for students upon completion of developmental courses to perceive themselves to be equivalent to their peers who enter directly into college-level mathematics. This suggests a need to look carefully at the affective impact of allowing students to move to the next level without adequate skills.

In our study, although there was a positive change in participants' self-perceptions (e.g., enjoyment), the overall postmeans were still in the middle of ratings on the 6-point scale. If remediation does not overtly address students' identities, as well as their level of skill, these students may be set up for failure in future mathematics courses. Research suggests that students' lack of enjoyment of a course/field of study can result in them having little engagement in and/or motivation towards the course (Pintrich & Schunk, 1996). Students should not leave remedial courses with mediocre self-perceptions of skills, beliefs, and attitudes.

The current study showed a 77-80% overall passing rate for students in developmental mathematics; those not completing the fall course had to retake it the following semester. This statistic is consistent with other four-year universities (e.g., Johnson, 2010). Unfortunately, the 20% who do not pass by the end of their first year are typically required to leave a university; the consequences of remediation are high-stakes. Furthermore, students who need remediation are far less likely to ever complete a degree (Bailey, 2009; Institute of Education Sciences, 1988). As discussed earlier, taking remedial courses is costly, delays graduation, and can dissuade students from seeking majors that require mathematics. Although intended to help support student success in mathematics, remediation can have negative consequences for students, and in some cases can become a barrier for future academic achievement (Noel-Levitz & CAEL, 2006).

Table 4

Pre vs. Postsurvey Results of Common Core Views Towards Mathematics

View	Question	Mean (*SD*) Pre	Mean (*SD*) Post	∆Mean	*p* value
Aptitude	Some people have a knack for mathematics and some don't.	3.26** (1.35)	4.61** (1.34)	1.35	$p < .0001$
Memorization	Mathematics involves mostly facts and procedures to be memorized.	4.57** (1.06)	4.29** (1.19)	-0.282	$p = .0012$

Note. **1 = strongly disagree, 6 = strongly agree

Table 5

Postsurvey Results: Are You Better at Math vs. Memorization and Instructor Helpfulness

Related Survey Item	Mean Ratings No	Yes (Due to recalling)	Yes (Due to learning)	Overall
Mathematics involves mostly facts and procedures to be memorized.	4.23*	4.42*	4.11*	4.29*
Overall, were your instructor and the instruction helpful? Please explain.	1.44**	1.64**	1.93**	1.79**

Note. *1 = strongly disagree, 6 = strongly agree; ** 0 = no, 1 = unsure, 2 = yes

Limitations of the Study

Study results are limited by both the sample size and urban, diverse location. Additionally, we chose to make the survey anonymous, thereby allowing participants to feel comfortable being honest about their background and experiences. However, this choice did limit our ability to compare surveys at the participant level, as well as across participants by specific aspects of background.

Adequate preparation for success in college is not merely a matter of how many courses students have taken.

Implications for Practice

One common theme in the literature on instruction in developmental mathematics courses is that no single set of practices will be effective with every student (Biswas, 2007; Schwartz & Jenkins, 2007). There is a broad consensus in the literature that educators ought to take a holistic approach to developmental education.

Expanded Curriculum and Attention to Affect

Our findings corroborate that adequate preparation for success in college is not merely a matter of how many courses students have taken but how well they do within them (Fong, Huang, & Goel, 2008) and how well they retain this knowledge and skills upon entering higher education institutions. The necessity to examine content and rigor of mathematics courses required for high school graduation is crucial as is aligning curriculum directly with expectations of colleges and universities. New curriculum efforts (e.g., Common Core State Standards for Mathematics) will ideally support K-16 education in re-examining curriculum and increasing quality and depth of mathematical exploration. Nontraditional students can be provided with information regarding previous courses/knowledge needed for success in college and guided to appropriate resources as needed.

Additionally, curriculum needs to be restructured to integrate new ideas of success, including alternate pathways to help facilitate students' expeditious and successful completion of remediation. Findings from our study suggest that objectives of remedial courses need to be re-evaluated to include student outcomes that focus on attitudes about mathematics in addition to content and skills– in line with developmental education's focus on developing the whole student—with parallel assignments that promote student investigations and reflections on mathematics that are interesting to students and motivate them to embrace the priority skill sets. For example, students could collect their own data (e.g., comparing cost of cell phone plans) and use algebra to model phenomena under investigation and analyze trends, make relevant decisions, and/or make predictions.

Essential to supporting students in developmental courses are effective instructors who utilize pedagogy that facilitates students in gaining a growth mindset and positive views toward learning mathematics. We believe that teaching developmental mathematics classes can be challenging, and the selection and training of instructors is crucial. Following this study, the mathematics department at CSULB began using only a specially selected set of part-time instructors and graduate teaching associates for these courses, as they are eager to attend annual training and often more sensitive to and accommodating of students' needs.

Developmental mathematics teaching and learning should help students to change from a fixed mindset to a growth mindset in terms of their perceptions on their own academic abilities; that is, their abilities will improve and they will become more successful if instructors make enough efforts and utilize available resources (Dweck, 2006; Howard & Whitaker, 2011). Educators must reflect carefully on the influence the remediation experience is or is not having on students' beliefs.

Precollege Intervention

As noted earlier, being eligible to attend college does not imply being ready for college coursework in mathematics. It is unfortunate that students are not usually aware that they are not fully prepared until the beginning of their first semester in college when they must take placement exams. Early intervention for students identified as underprepared for college-level coursework can lead to more efficient and effective methods to adequately prepare students before they complete high school, thereby giving them stronger skills at college entry and better positing them for success (Willett, Hayward, & Dahlstrom, 2008). For example, students could be tested for placement prior to admittance to a university/community college; they could then have time to re-test before official matriculation.

Achievements in mathematics at the onset of students struggling with mathematics can encourage and create early motivation that could contribute to student success in postsecondary institutions. Counselors at both the secondary and university/college levels need to make sure that students are aware of the serious ramifications of

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high-stakes testing and placement into and fulfilling remediation. Simultaneously, resources and supervision that encourages students are needed so that they feel supported and motivated and can simultaneously develop a positive math identity (Bishop, 2012). GEAR UP/pathway programs to increase college readiness are one example of such a resource. Students enrolled in GEAR UP are typically provided with alternative curriculum, academic support, and cohort membership (U.S. Department of Education, 2014). However, many such programs begin near completion of middle school. Although they aim to transition students from middle to high school, then ultimately college, their main focus is currently in schools rather than postsecondary institutions (Parker, 2007). Community colleges also play a role; for example, they currently operate about twenty-five percent of adult school programs in California, and with further cuts in K-12 education ongoing, they are preparing to take on the burden (Frey, 2012).

One noteworthy example of an effort to support early and effective remediation at the university level is the addition of summer sessions within the CA State University (CSU) system, the Early Start Initiative (California State University Board of Trustees, 2010), which have come into operational effect since the Summer of 2012. The numerous sessions are offered in multiple formats (e.g., 1-week, 4-week); students are advised into these special sections based on previous scores on a statewide secondary assessment. The goal is for the majority of these students to complete skill remediation prior to enrolling as matriculated freshmen.

Conclusion

Understanding who students are both as they enter and complete developmental math courses is essential to improving both potential for their success and pathways connecting secondary and college-level curricula. Findings from our examination of almost 400students in a semester-long section of the midlevel developmental mathematics courses (Intermediate Algebra) at a large, urban state university suggest that merely the number of years of mathematics that students take and pass in high school is not a precise indicator of student readiness. Results advocate for the re-evaluation of developmental courses to include (a) student outcomes that focus on attitudes about mathematics in addition to content/skills, as well as (b) pathways through which students can be made aware of the need for and supported in achieving success within remediation.

Every student should have the opportunity to pursue higher education if desired and be prepared for the level of academic rigor required if accepted. This study and the current situation with developmental mathematics suggest that educators must consider the whole student in determining both curriculum and pedagogy during remediation (e.g., previous experiences, affect, skills) and explore3 innovative approaches. As institutions undertake redesign of courses and support services (Bonham & Boylan, 2012) this research can inform such efforts and be replicated as part of a program evaluation. Furthermore, additional research should be conducted on when requiring remediation is appropriate for students; alternate pathways should be considered. Equally opportunistic alternatives should be presented for those not yet ready and/or not sufficiently skilled to pursue four-year degrees.

The goal is for the majority of these students to complete skill remediation propr to enrolling as matriculatedfreshmen.

References

Adams, C. (2013, January). Fewer incoming college students need remediation, research shows. *Education Week.* Retrieved from http://blogs.edweek.org/edweek/college_bound/2013/01/study_looks_at_incoming_college_students_needing_remediation.html

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college.* Washington, DC: U.S. Department of Education.

Anderson, L. W. (2002). Curricular alignment: A re-examination. *Theory Into Practice, 41*(4), 255-160.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185.

Attewell, P., Lavin, D., Domina, T., & Levey, T. (2006). New evidence on college remediation. *Journal of Higher Education, 77*(5), 886–924.

Bailey, T. (2009). *Rethinking developmental education in community college* (Issue Brief No. 40). New York, NY: Community College Research Center Publications.

Benken, B. M., & Brown, N. (2008, January). Integrating teacher candidates' conceptions of mathematics, teaching, and learning: A cross-university collaboration. *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal, 1,* 1-15. (EJ835493).

Bishop, J. P. (2012). "She's always been the smarter one. I've always been the dumb one": Identities in the mathematics classroom. *Journal for Research in Mathematics Education, 1*(43), 34-74.

Biswas, R. R. (2007, September). *Accelerating remedial math education: How institutional innovation and state policy interact* (Policy Brief). Boston, MA: Jobs for the Future.

Bonham, B., & Boylan, H. R. (2012). Developmental mathematics: Challenges, promising practices, and recent initiatives. *Journal of Developmental Education, 36*(2), 14-21.

Brown, R. S., & Niemi, D. N. (2007). *Investigating the alignment of high school and community college assessments in California.* San Jose, CA: The National Center for Public Policy and Higher Education.

California State University Board of Trustees. (2010, June). *Early start program* (Executive order 1048). Retrieved from http://www.calstate.edu/eo/EO-1048.html

California State University System. (2012). *Fall 2011 final regularly admitted first-time freshmen remediation system-wide* Retrieved from http://www.asd.calstate.edu/remediation/11/Rem_Sys_fall2011.htm

Cambell, J.W., & Blakey, L.S. (1996). *Assessing the impact of early remediation in the persistence and performance of underprepared community college students* (Annual Forum Paper). Albuquerque, NM: Association for Institutional Research. (ED397749)

Case, B., & Zucker, S. (2005, July). *Horizontal and vertical alignment.* San Antonio, TX: Pearson Education.

Creech, J.D. (1997). *Better preparation, less remediation. Challenging courses make a difference. Goals for education: Educational benchmarks* (SREB Report). Atlanta, GA: Southern Regional Education Board. (ED415741)

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed method approaches.* Thousand Oaks, CA: Sage.

Duranczyk, I. M., & Higbee, J. L. (2006). Developmental mathematics in 4-year institutions: Denying access. *Journal of Developmental Education, 30*(1), 22-31.

Dweck, C. S. (2006). *Mindset: The new psychology of success.* New York, NY: Random House.

Fong, A.B., Huang, M., & Goel, A.M. (2008). *Examining the links between grade 12 mathematics coursework and mathematics remediation in Nevada public colleges and universities* (Issues & Answers Report, REL 2008–No. 058). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory West.

Frey, S. (2012). *At risk: Adult schools in California* (Report). Mountain View, CA: Edsource.

Gamoran, A., Porter, A. C., Smithson, J., & White, P. A. (1997). Upgrading high school mathematics instruction: Improving learning opportunities for low-achieving, low-income youth. *Educational Evaluation and Policy Analysis, 19*, 325-338.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal of Research in Mathematics Education, 21*(1), 33-46.

Hill, E. G. (2008). *Back to basics: Improving college readiness of community college students* (LAO Report). Sacramento, CA: The Legislative Analyst's Office.

Ho, H., Senturk, D., Lam, A.G., Zimmer, J. M., Hong, S., Okamoto, Y., & Chiu, S. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education, 31*(3), 365-379.

Howard, L., & Whitaker, M. (2011). Unsuccessful and successful mathematics learning: Developmental students' perceptions. *Journal of Developmental Education, 35*(2), 2-15.

Institute of Education Sciences. (1988). *National education longitudinal study of 1988* (NELS: 88). Retrieved from http://nces.ed.gov/surveys/nels88/

Johnson, H. (2010). *Higher education in California: New goals for the master plan* (Research report). San Francisco, CA: Public Policy Institute of California.

Kargar, M., Tarmizi, R.A., & Bayat, S. (2010). Relationship between mathematical thinking, mathematics anxiety and mathematics attitudes among university students. *Procedia Social and Behavioral Sciences, 8*(1), 537-542.

Kraman, J., D'Amico, A., & Williams, M. (2006, August). *Paying double: Inadequate high schools and community*

CONTINUED ON PAGE 31

Community College Journal of Research and Practice, 28, 373-391. doi: 10.1080/10668920490424087

Zachry, E. M. (2008). Promising instructional reforms in developmental education: A case study of three *Achieving the Dream* colleges. New York: MDRC. Retrieved from http://www.mdrc.org/sites/default/files/promising_instructional_reforms_fr.pdf

CONTINUED FROM PAGE 22

college remediation (Issue Brief). Washington, DC: Alliance for Excellent Education.

Long, M.C., Conger, D., & Iatarola, P. (2012). Effects of high school course-talking on secondary and postsecondary success. *American Educational Research Journal, 49*(2), 285-372.

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*(1), 27-47.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Governors Association. (2010). *Common core state standards for mathematics*. Washington, DC: Author.

Noel-Levitz, & CAEL. (2006). *The 2006 national adult learners satisfaction-priorities report.* Iowa City, IA: Noel-Levitz.

Nord, C., Roey, S., Perkins, R., Lyons, M., Lemanski, N., Brown, J., & Schuknecht, J. (2011). *The nation's report card: America's high school graduates* (NCES 2011-462). Washington, DC: U.S. Department of Education, National Center for Education Statistics, U.S. Government Printing Office.

Parker, T. L. (2007). *Ending college remediation: Consequences for access and opportunity* (ASHE/Lumina Policy Brief No. 2). Ames, IA: Iowa State University, Department of Educational Leadership and Policy Studies.

Pintrich, P. R., & Schunk, D. H. (1996). *Motivation in education: Theory, research, and applications*. Englewood Cliffs, NJ: Prentice Hall.

Rosin, M. (2012, Febuary). *Passing when it counts: Math courses present barriers to student success in California community colleges* (Issue Brief). Mountain View, CA: Edsource.

Schwartz, A. E. (2007). New standards for improving two-year mathematics instruction. *Education Digest, 73*(2), 39-42.

Schwartz, W., & Jenkins, D. (2007). *Promising practices for community college developmental education: A discussion resource for the Connecticut community college system.* New York, NY: Community College Research Center, Columbia University.

Tobias, S. (1993). *Overcoming math anxiety.* New York, NY: W. Norton & Company.

U. S. Department. of Education. (2014). *New GEAR UP grants awarded to help more than 116,000 students get on the pathway for success in college* [Press release]. Retrieved from http://www.ed.gov/news/press-releases/new-gear-grants-awarded-help-more-116000-students-get-pathway-success-college

Willett, T., Hayward, C., & Dahlstrom, E. (2008). *An early alert system for remediation needs of entering community college students: Leveraging the California standards test* (Report 2007036). Sacramento, CA: California Partnership for Achieving Student Success.

Zelkowski, J. (2010). Secondary mathematics: Four credits, block schedules, continuous enrollment? What maximizes college readiness? *The Mathematics Educator, 20*(1), 8-21.

For Your Information

May

11-13, 2015 – Learning Specialists Association of Canada's (LSAC) 2015 National Conference "Transitions: People, Practice, Profession," at the University of Guelph in Guelph, Ontario. For more information http://learningspecialists.ca/pages/lsac2015

24-27, 2015 – National Institute for Staff & Organizational Development's (NISOD) 37th Annual International Conference on Teaching and Leadership Excellence at the Austin Convention Center in Austin, TX. For more information visit http://www.nisod.org/?q=products/conference

29-31, 2015 – The 12th Annual Teaching Professor Conference in Atlanta, GA. For more information visit http://www.magnapubs.com/teaching-professor-conference/index.html

June

4-7, 2015 – National Association of African American Studies (NAAAS) and Affiliate's 2015 Eastern Regional Conference at the Embassy Suites Tampa, Downtown Convention Center in Tampa, FL. For more information visit https://www.naaas.org/regional-conferences

7-10, 2015 – League for Innovation in the Community College's Learning Summit 2015, "Student Success and Completion," at the Maricopa County Community College District in Phoenix, AZ. For more information visit http://www.league.org/ls2015/

20 to July 17, 2015 – Kellogg Institute for the Certification of Adult & Developmental Educators at Appalachian State University in Boone, NC. For more information see ad, page 35, or visit www.ncde.appstate.edu/Kellogg

21-26, 2015 – NACADA's 29th Annual Academic Advising Summer Institute in New Orleans, LA. For more information visit http://www.nacada.ksu.edu/

24-26, 2015 – NACADA's International Conference, "Partnering for Student Success," at the University of Melbourne in Melbourne, Australia. For more information visit http://www.nacada.ksu.edu

25-26, 2015 – Community College of Baltimore and Accelerated Learning Program (ALP) Conference on Acceleration in Developmental Education at the Hilton Orange County/Costa Mesa, Costa Mesa, CA. For more information visit http://alp-deved.org/2014/12/2015-conference-acceleration-developmental-education/

28 to July 1, 2015 — National College Learning Center Association's 2015 NCLCA Institute, "Bridging the Gap to Student Success," at the Hyatt Regency in Greenville, SC. For more information visit http://www.nclca.org/institute.htm

July

8-10, 2015 – Ruffalo Noel Levitz National Conference on Student Recruitment, Marketing, and Retention in Boston, MA. For more information visit https://www.noellevitz.com

19-24, 2015 — Advanced Kellogg Institute, "Making Our Voices Heard in the Reform Conversation," at Appalachian State University in Boone, NC. For more information visit http://ncde.appstate.edu/kellogg-institute/advanced-kellogg-institute

21-26, 2015 – NACADA's 29th Annual Academic Advising Summer Institute in Colorado Springs, CO. For more information visit http://www.nacada.ksu.edu/

31 — Deadline for Proposals: National Association for Developmental Education's (NADE) National Conference, "Golden Opportunities: Building On 40 Years of Progress," at the Anaheim Marriott Hotel in Anaheim, CA. For more information visit http://www.nade2016.net/