A Curriculum Focus Intervention's Effects on Prealgebra Achievement

By David Yopp and Richard Rehberger

ABSTRACT: ***This paper discusses a pilot study of the effects of a curriculum focus intervention on students' prealgebra achievement. Elements of the intervention include identification of high-priority learning objective; structured repeatable testing; and a coherent, rubric-based feedback component. This research differs from traditional mastery learning research in that it focuses on a subset of high-priority learning objectives, as opposed to the entire curriculum, and focuses on assessing students' ability to structure, represent, and communicate their processes and thinking skills, as opposed to assessing only whether the solution and process are correct. Students in the treatment and control groups were given general (not mathematics specific) academic efficacy measures, a course-specific efficacy measure, and a common course final exam. Only the differences in the means on course-specific measures were statistically significant, with the treatment group outperforming the control group on both the course-specific efficacy measure and the final. A possible negative effect was that students in the treatment group dropped out at a higher rate than students in the control group.***

Though the phrase a "mile wide and an inch deep" was coined to describe school mathematics (Schmidt, McKnight, & Raizen, 1997), it is also very descriptive of many 1st-year college courses. Postsecondary developmental algebra sequences—pre or introductory algebra and intermediate algebra—are often dense with topics, push students at a breath-taking pace, and cover many of the same topics in both courses, as if closure is neither expected nor achieved.

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This curriculum issue was noted by Steinfort (1996) who reported on a collaborative effort by 14 Michigan community colleges to reform their developmental algebra curriculums. Steinfort wrote that one of the problems motivating the reform was that "as mathematics educators, we were racing through material with lack of realistic applications, and there was too much course content for effective conceptual understanding. In addition, many of us were re-teaching Elementary Algebra topics in Intermediate Algebra" (p. 2). More recently, Epper and Baker (2009) criticized current best-selling community college developmental mathematics textbooks and software packages, asserting they replicate K-12 curriculums by presenting long lists of seemingly unrelated topics.

Yet textbooks and software packages that are packed with topics do not appear to reflect the curriculum desires of college developmental mathematics teachers. As reported in the ACT National Curriculum Survey 2005-2006 (ACT, 2007), which asked teachers what they find to be important about curriculum, "postsecondary mathematics teachers of entry-level and remedial courses agree in favoring 'depth' and rigorous understanding of fundamental skills, whereas high school mathematics instructors more highly value 'breadth'" (ACT, p. 20). In this study, remedial mathematics teachers "consistently rated understanding of fundamental mathematics as more important than exposure to more esoteric mathematics content topics for success in their courses" (ACT, p. 19). However, the ACT survey fell short of identifying exactly which topics are important enough to be called fundamental by developmental mathematics teachers. As Epper and Baker (2009) point out, "while there is broad agreement on the importance of both computation fluency and conceptual understanding, the issue of which skill should be taught, and in what order, has not been resolved" (p. 4).

Thus, there is a need for research that identifies the most important concepts and skills for each course in the developmental algebra sequence and that also examines the achievement effects for students who master those topics. This article serves as a starting point for such research by reporting a pilot study which shows that when a small subset of *high priority* learning objectives for a prealgebra course is identified and agreed upon by the faculty at an institution, it is reasonable to expect students to master these objectives completely (in terms skill proficiency and standards-based proficiency such as students' abilities to structure and communicate their responses), not simply come close. It is also shown that students who do achieve mastery on these high-priority learning objectives display a measureable positive effect in their mathematical achievement as measured by the course's

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common final exam and their mathematics self-efficacy beliefs.

This research differs from traditional mastery learning research in that it focuses on a subset of high priority learning objectives, as opposed to the entire curriculum, and focuses on assessing students' ability to structure, represent, and communicate their processes and thinking skills, as opposed to assessing only whether the solution and process are correct.

Mastery Learning and Feedback Research

The concept of mastery learning is not new to education. The 1920s and 1930s saw several systems of instruction requiring mastery on formal assessments before students were moved to new material (Bloom, 1968; Kulik, Kulik, & Bangert-Drowns, 1990). Possibly best known today is the work of Benjamin Bloom from the late 1960s and early 1970s, which he called Learning for Mastery (LFM). Motivated by his classroom observations that teachers rarely varied their instruction practices to fit individual learners' needs, Bloom devised a mastery process in which the curriculum is divided into units that are then taught, formatively assessed, and, if needed, retaught and reassessed (Gusky, 2005).

Required in Bloom's model is that this first assessment be followed by immediate "individualized" corrective instruction for those students who need it and enrichment activities for those students who don't. Once students receive corrective instruction, they are then reassessed prior to the entire class moving on to the next instructional unit. Over the years, several studies have linked LFM to positive effects on student achievement (Kulik et al., 1990).

Also associated with the term "mastery" is Keller's Personalized System of Instruction (PSI; Keller, 1968). PSI is similar to LFM in that the course materials are divided into units to be mastered before moving on to the next unit. PSI differs from LFM in that lessons are largely presented through written materials, which students move through at their own rates. PSI students who fail unit quizzes must retake quizzes until they are able to demonstrate mastery. PSI has also been shown to increase student achievement (Kulik et al., 1990).

Criticisms of LFM and PSI include that LFM requires users to design a supplemental curriculum for learners who demonstrate mastery on the first attempt and that PSI programs may allow learners to continue struggling at their own pace semesters after other students have completed the entire course. The latter is in contrast to the Kulik et al. (1990, p. 286) finding that the largest effect sizes occurred in mastery programs that required students to move through course materials at the teacher's pace, not the student's individual rate. Another criticism is that students who experience PSI or LFM instruction appear to drop out at a higher rate when compared to students who experience conventional instruction (Kulik et al.).

One aspect of the programs that has not been criticized is their use of feedback. Both LFM and PSI placed heavy reliance on a feedback loop, arguably the most prominent feature of these programs. In their original discourse, both Bloom and Keller expounded emphatically on the importance of feedback to their programs. Bloom (1968), for example, emphasized that the feedback loop between an excellent tutor and his or her students was what he sought to model. Similarly, Keller (1968) went to great lengths to downplay lecture and glorify the postassessment feedback process between a "proctor" and student. Moreover, in their meta-analysis of mastery programs, Kulik et al. (1990) reported that the strongest positive effect sizes come from mastery studies that used control subjects who received less feedback on quizzes than treatment subjects. They further reported that equating the amount of feedback between the control and treatment groups reduced the "size of the effect." Couple this finding with the finding of Marzano, Pickering, and Pollack (2001)–that feedback can be one of the most powerful single modifications to classroom practices for increasing student achievement in its own right–and one cannot help but wonder what portion of the positive effects from mastery learning can be attributed to the feedback loop alone.

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When the feedback component is eliminated from a mastery program, the program is more commonly called *repeatable testing*. Mixed results have been reported for repeatable testing. Juhler, Rech, From, and Brogan (1998) found that repeatable testing increased scores on the test being repeated but found no increase on students' final exam scores. Fehlen (1976) on the other hand found strong positive results for repeatable testing. In his study, three treatment groups were used, two of which were given the option of repeating assessments. Of these two treatment groups, one included mandatory tutoring. Fehlen contended that there was little difference between the effects for the tutoring and nontutoring groups, and he argued that repeatable testing was the factor that accounted for the positive gains. In contrast, Dunkelberger and Heikkinen (1984) found no supporting evidence that repeatable testing "by itself" contributed significantly to student achievement. Dunkelberger and Heikkinen did mention that tutoring was available to treatment students but gave no indication as to whether it was utilized.

Neither Fehlen nor Dunkelberger and Heikkinen discuss feedback in detail, and therefore it cannot be assumed that the term "tutoring" includes a well-defined feedback component. Since both Bloom and Keller use the term "tutoring" for contexts in which feedback on students' work is a critical component, and Fehlen and Dunkelberger and Heikkinen do not expound on the meaning of the term, the Fehlen and Dunkelberger findings shed little light on the importance of feedback in the mastery process.

Although it may be difficult to isolate the effect of feedback in the mastery learning process, much is known about how to maximize feedback's effect. According to Marzano et al. (2001), the strongest effects come from feedback that is corrective, timely, and criterion-referenced (i.e., feedback that indicates the specific "level" of the knowledge). Criterion-based feedback is distinct from norm-referenced feedback, which informs students where they stand in relationship to other students, in that it focuses on specific, well defined learning objectives. To achieve criterion-referenced feedback, Marzano et al. suggest using a scoring rubric.

The power of a scoring rubric appears to go beyond its use as a vehicle for feedback. It also better equips educators in communicating achievement standards to students prior to the assessment. Schafer, Swanson, Bené, and Newberry (1999) have found that students of teachers trained in their 4-point scoring rubric had statistically significant higher achievement scores on both selected response items (multiple choice) and constructed response items (open response), suggesting that knowledge of the rubric produced a learning advantage that generalized across assessment formats.

The Focus Intervention Compared to Mastery Learning

Because Bloom (1968), Keller (1963), and Kulik et al. (1990) have stressed the importance of coupling a feedback process with repeatable testing, the intervention described in this article (the Focus Intervention) incorporates a well-structured feedback loop after each assessment.

Yet, despite the use of repeatable testing and a formative assessment/feedback loop, the Focus Intervention is not "mastery learning" in the canonical sense. The biggest difference is that in the Focus Intervention the curriculum is not subdivided into units of content to be mastered before moving onto the next unit of content. The researchers in this study do not believe that all the content in a mathematics curriculum is of equal weight, nor do we believe that all content should be mastered immediately. Marzano et al. (2001), for example, have summarized research that suggests it takes 25 repetitions to achieve 70% proficiency on new skills and upward of 1000 repetitions for 100%.

Further, the question of when and what topics should be mastered is particularly problematic in mathematics. In mathematics, many topics are foundational and are utilized continually throughout the course. Therefore, the repetition needed often occurs within other contexts. Thus, the Focus Intervention considers the curriculum as a whole and identifies subsets of content deemed of very high priority (possibly even among the most important concepts, procedures, and problem strategies to be taught in the course) by a panel of experts. Further, the intervention focuses not only on the knowledge needed to solve the problems but also on the students' abilities to communicate that knowledge using the language of mathematics, an important objective of any prealgebra course.

Another difference between the Focus Intervention and "mastery learning," as originally proposed in LFM and PSI, is the requirement that students achieve 100% mastery on the items to receive credit for the assessment. Bloom (1968) has never defined a level of mastery in terms of a percent. Instead, he targeted moving 90% of the students to the level of mastery typically obtained by the top 5% of students. Keller (1968), as mentioned earlier, has relied heavily on the judgment of the proctor to determine if a student had mastered the content. More recent researchers have defined mastery levels in a rather ad hoc way. Kulik et al. (1990, p. 268) report that some studies used percent correct criteria as low as 56%. However, they also report that the "especially large" effect sizes are associated with studies defining the mastery criteria as 100% correct.

Thus, the Focus Intervention promises to examine a gap in the literature beyond the question of whether prealgebra students can be expected to master learning objectives completely. Specifically it examines the question: Is it also possible to produce positive effects on student performance with a focused mastery program that includes a strong feedback component within the constraints of conventional instruction that does not divide the curriculum into units assumed to be of equal importance?

Research Questions

To clarify, the research questions are restated as follows:

- If a small subset of high-priority learning objectives for a prealgebra course is identified and agreed upon by the faculty at an institution, is it reasonable to expect students to master these objectives completely (in terms of skill proficiency and standards-based proficiency such as students' abilities to structure and communicate their responses), not simply come close?
- Will students who achieve mastery on these high-priority learning objectives display a positive measureable effect in their mathematical achievement as measured by the course's common final exam?
- Will students who do achieve mastery on these high priority learning objectives display a positive measureable effect in their academic beliefs and strategies?

Method

Site and Participants

The study was conducted at a doctoral-granting public university in a western state. The classes were taught by full-time faculty who exclusively taught developmental students at an extension of a 2-year campus. The prealgebra course studied was the lowest level of mathematics offered; students were placed into the course with standardized mathematics test scores lower than 21 ACT, 490 SAT, or the equivalent on a department-developed placement test. Although the vast majority of students in the study were enrolled at the 4-year campus (92%) the course was designated as below college level. Twenty-two percent of the students in the study were admitted to the university provisionally, meaning that they did not meet the minimum requirements for admission, were restricted to 14-credit hours, and were required to take developmental courses in mathematics and English in their 1st semester. The mean number of credit hours attempted by the students during the study was 12.4 ± 3.6 (mean ± SD) with 86% of the students designated full-time (more than 7 credits). Students were split closely with respect to gender (53% male). The group was predominately White (86%), with 8% Black, 3% Hispanic, and 3% not reporting. The mean student age was 22.4 ± 6.1 years. Student ages ranged from 17- 50, with 22% of the students nontraditional in age (over 24-years old). Students who did not take the final exam were excluded from the data and discussion.

Control and Treatment Group Selection

In the Spring 2008 semester, treatment and control college-level prealgebra classes were randomly selected from two instructors' course assignments. One instructor (the second author) was assigned three sections, and two of his courses were randomly selected as treatment (Focus Intervention). The other instructor was assigned two sections, and one of her classes was randomly selected as treatment. The two remaining sections were used as control groups. These courses had very small enrollment. The treatment group contained 21 students, and the control group contained 15. Table 1 illustrates this breakdown by instructor.

Table 1

Courses in the Study

Section	Number of Students	Treatment or Control	Instructor
01	10	Control	A
02	10	Treatment	A
04	7	Treatment	B
05	5	Control	B

The Focus Intervention Experimental Procedure

A focal-point test (FPT; see Appendix A), was developed by the two prealgebra teachers and then evaluated for content and appropriateness by the other five faculty teaching subsequent courses. The first focal-point assessment was administered a few days after the midterm point in the course. Three parallel versions were made available for students who did not receive 100% mastery on the assessment. No changes to the curriculum or structure of the course were needed to accommodate the Focus Intervention. Students in both the treatment and the control groups were given practice versions of the focal-point assessment. Students in the treatment group were given the rubric (see Appendix B) and told that they must obtain a score of 100% based on the rubric or they would be assigned a 0%. Students who did not receive 100% were required to meet with the instructor one-on-one during office hours to get individualized feedback before being allowed to

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retake the FPT. Students in the control group were not told they needed to master the material. They were told instead that the assessment would count heavily towards their grade.

The focal-point assessment was then given to both the treatment and the control groups as an in-class test. The control group's work was graded by the instructor in a manner consistent with the other tests in the course. To address concerns that the treatment group simply had more exposure to the problems on the assessment, the control group was allowed to rework the missed problems outside of class for half of the missed points back. (It should be noted that a few students in the control group chose not to rework the assignment, despite the fact that both the instructors and a free tutor were available to help students rework problems and that, in some cases, these points would have significantly improved the student's standing in the course.)

For students in the treatment group who did not master the assessment on the first try, individual feedback meetings were held with the instructor. These meetings consisted of a discussion with the student regarding how his or her work and communication was measured with respect to the rubric. After the meeting, students could then schedule a retake of the problems not yet mastered with a proctor outside of class (repeatable testing). The process would repeat until the student mastered all of the problems or had taken the assessment four times. Students were told that if they did not receive 100% by the fourth assessment, they would receive a 0 for the assessment.

The decision to allow students to take the assessment only four times was made for both practical and pedagogical reasons. Pedagogically, it was believed that more than one attempt at the assessment was needed for the feedback loop to be effective. However, a limited number of attempts was also needed to encourage students to make every effort to pass the assessment on every attempt. Also, the authors had done single-course pilots (without the self-efficacy measures) and found that a few students were unable to pass the assessment on a third attempt. This suggested more than three attempts might be needed. Practical considerations, such as the amount of time an instructor had to devote to the grading and feedback process, influenced the decision to allow only four attempts at the assessment.

The unit of analysis was the students. Comparison of the treatment and control was performed using available SAT and ACT data and scores from the courses' first four unit assessments, which were the same exams for all sections. SAT mathematics data was available for five treatment students and four control students, with means and standard deviations of 422 (*SD*=54.5) and 417.5 (*SD*=69.46). ACT mathematics data was available for 10 treatment and 9 control students, with means and standard deviations of 16.9 (*SD*=1.72) and 16.3 (*SD*=1.73). Twenty-six percent of the students did not submit either ACT or SAT data (enrollment into this course, as the lowest level mathematics course, did not require placement data).

Table 2

Factor Analysis Summary for Items on the MSES2

Factor	Items and Loadings	Proportion of Variance Explained
1 (Working with different number representations)	Item 1–.499 Item 2–.653 Item 3–.917 Item 6–.736	.308
2 (Working with integers and equations)	Item 4–.678 Item 5–.860 Item 7–.578	.246

The most consistent comparison data were the students' performance on the first four course unit assessments. The treatment group mean was 90.87 (*SD*=0562) and the control group mean was 89.33 (*SD*=0744). A *t*-test did not reject the null hypothesis that these group means were equal (t=0.71, p=.4847), so one could assume group means were equal.

Measures

Statistical analysis of the three following measures was performed using R, a language and environment for statistical computing, (R Development Core Team, 2007) and the R package ltm (Rizopoulos, 2006). In many cases, the sample sizes needed for robust statistical analysis were not available in this study. In such cases, the statistical results are reported with the limitations disclosed. Despite the limitations, the reported analysis is likely to be useful to future researchers or practitioners in designing similar studies.

Mathematics Self-Efficacy (MSES2). The instrument in Figure 1 was modeled after the Mathematics Self-Efficacy Scale (MSES; Nielsen & Moore, 2003). Shown to be valid and reliable for students whose ages range from 14 to 16, the MSES involves student self-assessment of competence in relation to specific mathematics tasks. Because the curriculum encountered by students in this age range has many similarities to curriculum encountered in the prealgebra course in this study (topics include operations on fractions, decimals, ratios, proportions, percents, signed numbers, and one-variable equations), the MSES was believed to be a good model for the development of instrument for this study's adult audience.

The seven questions on the MSES2 (see Figure 1) resulted from adapting questions from the MSES to this study's college audience and were ordered randomly. The survey was given at the beginning of the semester (pretreatment) and at the end (posttreatment) to participants in both the treatment and control groups. Results from the 36 students' pretreatment surveys were used for a reliability and validity check. Construct validity was checked using factor analysis.

For factor analysis, Bryant and Yarnold (1995) assert that the ratio of subjects to items should be no lower than that five, and this sample meets that criterion. However, Bryant and Yarnold also endorse a "rule of 200," which asserts that sample sizes should include at least 200 subjects. This criterion is not met by the sample.

The survey showed strong internal reliability (Cronbach's alpha=.802), and factor analysis did not reject the null hypothesis that the survey contained 2 factors: working with different

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The following questions ask you to estimate you own mathematics ability. On a scale of 1 (not at all confident) to 5 (very confident), how confident are you that you can perform each of the following mathematics tasks in a mathematics test?

1. Work with fractions.
2. Work with percents.
3. Work a problem using proportions.
4. Work with whole numbers.
5. Work with negative numbers.
6. Work with decimals.
7. Solve an algebraic equation.

Figure 1. **Questions developed for the MSES2 using the Mathematics Self-Efficacy Scale as a model.**

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number representations and working with integers and equations. The only surprising finding was that item 7, working with equations, correlated with a factor containing items 4 and 5, working with whole and negative numbers. A possible explanation is that the algebraic equations solved in this course were linear and the majority of these equations involved integer coefficients (whole numbers and negative whole numbers). Further, the procedures involved in solving these equations—such as order of operations and use of distributive properties—very closely mimic procedures for simplifying integer expression, a prerequisite for solving equations. Thus, the difficulty students have manipulating integer expressions is likely carried over to solving algebraic equations containing these expressions. Table 2 summarizes the results.

The survey also showed predictive validity. The treatment and control groups' posttreatment MSES2 survey was moderately correlated with the students' final exam scores (r=.489, p=.0025), explaining roughly 25% of the variance on the final exam.

General Academic Beliefs (GAB). The second survey (see excerpts in Figure 2) was designed to measure more general self-efficacy, intrinsic value, test anxiety, cognitive strategy use, and self-regulation. The survey was created by selecting items from the Motivated Strategies for Learning Questionnaire survey. Pintrich and DeGroot (1990), who examined the survey's reliability, validity, and categorical correlations to academic performance for seventh-grade science and English students. Items were ordered randomly and numbered as in Figure 2. The survey was given at the beginning of the semester (pretreatment) and at the end (posttreatment) to participants in both the treatment and control groups. Results from the 36 students' pretreatment surveys were used for a reliability and validity check. The ratio of subjects-to-variables did not meet the "rule of 200" endorsed by Bryant and Yarnold (1995) and, therefore, validity inferences should be noted with caution.

The survey showed strong internal reliability (Cronbach's alpha=.722), and factor analysis did not reject the null hypothesis that the survey contained 4 factors. The first factor contained three items from each of the categories intrinsic value, cognitive strategy use, and self-regulation (B, D, E) for a total of nine items. Factor 2 contained all of the items from self-efficacy (A) and factor 3 contained all four items from text anxiety (C). The fourth factor only explained approximately 5% of the survey data's total variation and was not viewed as important. Test anxiety and self-efficacy do appear to form their own factors or constructs whereas the remaining items appear to form a separate construct. The fact that three categories correlated with the same factor is not surprising since Pintrich and DeGroot (1990) found these variables highly correlated (p<.001).

Course final exam. A comprehensive final was given at the end of the semester. This final contained 35 items designed and selected by a team of five experienced instructors of the course (face validity). The final was multiple choice and items were either correct or not. Old final exam data was combined with final exam data from this study to determine its validity and reliability, n=117.

The final showed moderate internal reliability (Chronbach's alpha=.628). Principal component analysis was used to explore components within the assessment. Using the Kaiser Criteria (drop all components with eigenvalue less than one), no components were identified. The fact that the final exam score for students in the study showed moderate correlation (r=.489) with the MSES2 data demonstrates some convergent validity of the final.

(Rank 1 to 7. 1=not at all true for me. 7=very true for me.)

Motivational Beliefs:

A. Self-Efficacy
   5. I'm certain I can understand the ideas taught in this course.

B. Intrinsic Value
   4. I think that what we are learning in this class is interesting.

C. Test Anxiety
   3. I am so nervous during a test that I cannot remember facts I have learned. (Reverse)

D. Cognitive Strategy Use
   17. When learning new math I try to connect the new ideas with math I already know.

E. Self-Regulation
   24. I ask myself questions to make sure I know the material I have been studying.

Figure 2. **Selected questions from the General Academic Beliefs Survey developed using Motivated Strategies for Learning Questionnaire as a model.**

Results

Data Analysis

Multivariate Analysis of Variance (MANOVA) was performed with the independent variable treatment (1) or control (0) and dependent variables of the final exam score and the gains (post-pre) on the MSME2 and the GAB (parts A, B, C, D, E, B+D+E each representing their own dependent variable). The null hypothesis was that the mean scores on each of the measures (the dependent variables) were the same for both groups, treatment and control:

$$H_0 : \begin{pmatrix} \mu_{1,c} \\ \mu_{2,c} \\ \vdots \\ \mu_{8,c} \end{pmatrix} = \begin{pmatrix} \mu_{1,t} \\ \mu_{2,t} \\ \vdots \\ \mu_{8,t} \end{pmatrix},$$

where $\mu_{i,j}$ represents the mean score for the i^{th} measure (ordered as listed above) for the j^{th} group, treatment (t) or control (c). This analysis was followed by t-tests to determine which variables represented statistically significant differences between treatment and control. Correlation coefficients were examined for all

Table 3
MANOVA on Final Exam Scores and MSME2/GAB Scores

	df	Pillai's Trace	approx F	*df*	Pr(>*F*)
Treatment Versus Control	1	0.40096	2.25899	8	0.0542
Residuals	34				

Table 4
t-Test Results for Individual Measures

Measure	**Treatment (*n*=21)**		**Control (*n*=16)**		***t* (*p*-value)**
	Mean Gain/Score	***SD***	**Mean Gain/Score**	***SD***	
GAB Part A	-0.76	6.36	-2.27	5.34	0.75 (.4601)
GAB Part B	0.05	4.33	-1.33	2.02	1.15 (.2600)
GAB Part C	2.05	5.85	0.07	4.93	1.07 (.2927)
GAB Part D	-6.81	4.89	-9.80	4.89	1.09 (.2843)
GAB Part E	-2.00	8.25	-2.60	3.07	0.27 (.7903)
GAB Parts B,D,E	-8.76	21.49	-13.73	8.23	0.85 (.4015)
MSES2	6.57	5.69	2.33	4.47	2.40 (.0219*)
Final Exam	0.9076	0.0837	0.8527	0.0708	2.13 (.0406*)

**Denotes difference significant at the* .05 significance level (two-tailed) posttreatment measures. Statistical analysis was performed using R language and environment for statistical computing (R Development Core Team, 2007). Table 3 summarizes the results of the MANOVA. Overall, the differences in means of the dependent variables are significant at the 10% level (p=0.0542).

Table 4 summarizes the results of t-tests performed on individual measures. GAB measures intrinsic value, cognitive strategy use, and self-regulation ratings were combined for one rating (based on the factor analysis). The mean of this rating declined for both the treatment and control group. Although the mean decline was smaller for the treatment group than the control group, hypothesis testing suggested the difference in the observed means was due to chance. A similar result was found for the self-efficacy measure. The mean ratings for test anxiety (items reversed in Table 4) also decreased for both groups. The mean decrease was larger for the treatment group but hypothesis testing suggested the difference in the observed means was also due to chance.

The findings for the generic instrument (GAB) are interesting when compared with the subject-specific instruments (MSES2 and the final exam). Both of these subject-specific measures showed that the treatment group outperformed the control, and the results are statistically significant. Also interesting is the fact that both treatment and control had positive gains on the subject specific self-efficacy instrument but negative gains on the generic self-efficacy instrument.

Table 5 (p. 34) shows the correlation matrix for all posttreatment measures. All 36 students (treatment and control) are included in the analysis. Note that all of the measures from the GAP correlate, and this correlation is statistically significant. This finding is consistent with that of Pintrich and Groot (1990). Table 5 also shows only MSES2 as a significant predictor of the final exam and that this measure exhibits statistically significant correlation only with the test anxiety measure from the GAB. This finding suggests that test anxiety is related to subject-specific self-efficacy beliefs. In summary, the larger mean gains, treatment group over the control group, were statistically significant only on course-specific measures: the MSES2 and final exam.

Retention Data

The effect of the Focal Point Intervention on the retention of students may be hard to assess by this study. Raw data indicate that retention (percent of students on the 15th day of class who complete the course) in the treatment

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class (64%) is lower than in the control (73%), which would be consistent with other mastery programs. However, it should be noted that the focal-point assessment was not given until the second half of the semester and that that many of these students withdrew from the course prior to administration of the Focus Intervention.

Case Study

The following case study and qualitative analysis is presented to illustrate the specifically mathematical changes that the Focus Intervention causes in students and to support the positive findings of this study. The student in this case study had failed or withdrawn from five lower-division mathematics classes within the past 4 years (one attempt at prealgebra, one attempt at geometry, and three attempts at number theory). On two occasions she reported that a previous instructor informed her that she would never "get math" and she should "stop trying and do something else."

She began the treatment class with high motivation but a significant lack of ability. It was not clear from her early classroom assessments that she'd learned or retained any content in her previous prealgebra class coursework. Prior to completing the Focus Intervention, she'd taken seven chapter tests, and her scores on each of these were passing but below average. Her work on homework and tests was hard to follow, a jumble of scratch work and multiple approaches. She displayed particular difficulty with signed numbers, basic algebraic manipulation, and any multistep problem. Figure 3 illustrates two examples of the student's typical work before the intervention and were both taken from the first attempt at the focal-point test. Although many of the computations are done correctly, signs, parentheses, and equation structure disappear immediately as she begins solving the problem. Numbers appear and disappear as the student focuses on single steps with no coherence to the overall objective of the problem. By the end of her solving attempt, several errors have been made. It is the opinion of the authors that the student's limited proficiency in structured writing and use of math vocabulary, symbols and communication skills prevent her from solving the problem correctly.

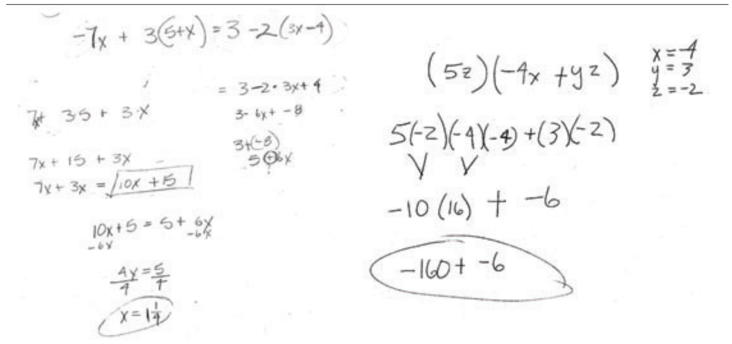

Figure 3. **Two examples of student problem solving before the Focus Intervention.**

These behaviors appear to be typical of developmental students and were clearly present in other students in the class. Although many students can perform single mathematical tasks or manipulations with some accuracy, they fail in solving multistep problems due to their inability to unite individual steps into a coherent problem-solving strategy. Students get lost in their own writing and lose focus on the problem's original objective. Using a traditional method of partial credit, it is possible for many such students to receive passing scores without being able to completely solve any single problem.

Figure 4 shows the student's fourth attempt on the focal-point assessment. It demonstrates improvements in organization, communication, and language of mathematics and in working a multistep problem. The student is presenting her manipulations in sequential order and maintaining the overall objective of the problems, as opposed to breaking the equation into pieces or changing the meaning of the expression by moving parentheses as in Figure 3. When required to organize and communicate her solution, the student demonstrates an improved understanding of the distributive property, the correct meaning and use of parentheses, and combining like terms (clearly absent in Figure 3).

Figure 5 illustrates two similar problems taken from the student's final exam. These problems illustrate that the improvements seen in Figure 4—structure, communication, math vocabulary, and symbols use–were maintained after the Focus Intervention was complete. (The final exam was given 2 weeks after she completed her final focus-intervention assessment.)

It is the opinion of the authors that the mastery/feedback intervention was the catalyst for the improvements. The student received substantial feedback on many occasions prior to the first intervention but did not make the changes until held accountable to a 100% mastery criteria reference with a well-defined rubric.

This case study shows the specifics regarding why the method is efficacious. By focusing on specific problems and specific rubric-based criteria, the instructor had a basis for addressing shortcomings in a criterion-referenced way, as opposed to saying "this is wrong."

Table 5

Correlation Matrix for Individual Measures

	A	B	C	D	E	B,D,E	MSES2	Final
A	1.000							
B	.577**	1.000						
C	.550**	.254	1.000					
D	.800**	.692**	.554**	1.000				
E	.457**	.766**	.375*	.751**	1.000			
B,D,E	.683**	.865**	.462**	.921**	.929**	1.000		
MSES2	.307	.240	.384*	.288	.131	.241	1.000	
Final	.238	.229	.136	.091	-.071	.067	.489**	1.000

N=36 * ± .329 critical value .05 (two-tail) ** ± .424 critical value .01 (two-tail)

Discussion

The importance of structured and focused feedback and mastery for students was supported by this pilot study. Student motivation and interest in the course was hard to quantify, but there were differences between the treatment and control groups noted in the data. Less formally, the instructor (2nd author) noted course participation in and outside of lecture, and interest in course content appeared higher among the treatment group than among the control group at the end of the semester. After receiving repeated personalized feedback focused on their reasoning skills, communication, and use of correct math notation, treatment students appeared to exhibit positive changes in attitudes and mathematical abilities. We pose that this positive change was due to the Focus Intervention as it provided students with a content focus and an opportunity to receive high-quality feedback on content

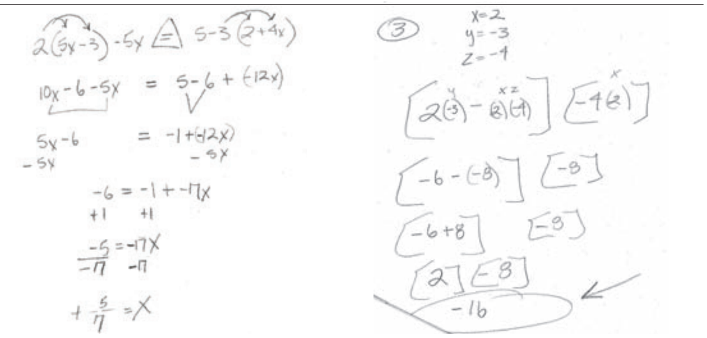

Figure 4. **Example of case-study student's problem solving on the fourth attempt on the focal-point assessment.**

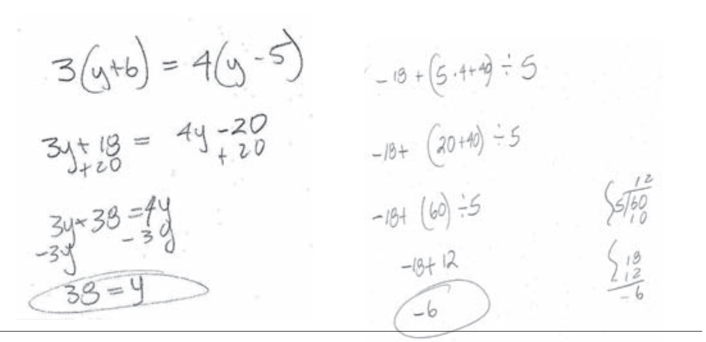

Figure 5. **Except from case-study student's final exam.**

topics in a one-on-one, structured environment. In that sense, the Focus Intervention likely increased students' understanding of how to effectively use faculty office hours as a feedback component.

It should be noted that the only statistically significant gain came from course-specific measures. Although the mean gains of the treatment group were larger (or decreased less) than those of the control group in all measures, nonmathematics-specific measures were not shifted in a significant way. This finding suggests that differences in gains on nonmathematics-specific measures could have been due to chance and that generic academic attitudes and beliefs may be difficult to change in a single specific course.

Limitations

Several limitations of the study exist. First, this intervention was designed around a specific course at a specific institution. Generalizations of the findings should take into account the targeted population's learning needs and the specific course objectives.

Second, the validity checks involving factor analysis of the study's instruments lack the population size necessary for robust statistics. A strength is that the GAB and MSES2 survey items were extracted or modeled from existing valid and reliable instruments; however, caution should be used when applying the instruments to different populations.

Third, the final exam did not go through the full psychometric analysis necessary for complete validity and reliability assurances. A strength was the final exam's face validity and that it exhibited some convergent validity to the MSES2 gains.

Implications for Practice and Future Research

It is the opinion of the instructors involved in this study that the Focus Intervention would be easy to modify and implement into nearly any traditional mathematics course with little or no changes to the curriculum. The positive results from this study suggest that traditional classrooms could benefit greatly from implementation with little or no inconvenience to the instructor.

To implement the Focus Intervention into a mathematics course different from the one discussed in this article, the instructors at an institution should meet and collectively agree on which learning objectives are deemed high-priority for that particular course. This is an institution-based decision since college mathematics courses are often preparatory for subsequent courses, and specific content needs may differ among institutions. Instructors should also identify which assessment criteria are important. Some instructors place more emphasis on problem-solving approaches, whereas others value how students represent, communicate, and explain their solutions. Because assessment criteria communicate expectations to students, conversations about assessment criteria should be connected to conversations about which mathematics habits are important for student success. This process can send clear messages to students about how to learn mathematics effectively.

Once the high-priority topics and assessment criteria are agreed upon, five parallel versions of the focal-point assessment and a corresponding scoring rubric should be created. Efforts should be made to ensure the assessments are parallel. Faculty should agree that the assessments appear to assess the same material, which increases a type of validity of the assessments, known as face validity. Validity can also be increased by piloting the assessments with a sample of students. This would help determine if the assessments actually assess what is intended and if items assumed to be parallel are actually answered in a similar way by students. A strong, well-structured feedback component should be made available after each assessment. To ameliorate the faculty time commitment necessary to provide such feedback, tutors, graduate assistants, Supplemental Instruction leaders, and academic support staff can be enlisted and trained to provide such feedback.

The Focus Intervention also could be adapted to distance education settings by making the assessment available in a testing center or online, if a mathematical typesetting environment is available. Otherwise, the assessments could be printed and mailed. Because a strong and thorough feedback component appears to be vital to the success of the Focus Intervention, an interactive environment such as a chat room or phone conversations should be made available.

Given the positive results observed in this pilot study, future research is warranted. Pilot studies like this offer evidence that the effort, time, and expense needed to run a large-scale study with a rigorous research design are justified. Future research could also focus on longitudinal tracking of Focus Intervention students to answer questions of whether students exposed to the Focus Intervention maintain achievement gains in subsequent courses and whether they exhibit and maintain changes in their study habits, attitudes about mathematics learning, use of feedback, and use of instructional resources such as faculty office hours. Although this study lacks the experimental research design and sample size needed to generalize the findings, the study does offer the classroom teacher a model, including measures for examining the effects of the Focus Intervention in his or her own classroom. In more general terms, this study might encourage instructors to engage in small-scale studies in their own classrooms. Such research is often termed action research. It involves instructors indentifying weaknesses in their classrooms, reviewing the literature for appropriate interventions and measures, implementing interventions, and reflecting on the effects of interventions using qualitative and quantitative means. Such processes allow instructors to judiciously implement ideas from published education research into their classroom practices.

Conclusion

Developmental algebra curriculums are often too dense with topics (Baker, 2009) which are presented at such a rapid pace that many topics are not completely understood or mastered by students (Steinfort, 1996). Instructors who feel bound by established curricula may have difficulty narrowing their curriculum. The positive findings of the Focus Intervention pilot study suggest that instructors can select a small subset of high-priority learning objectives and expect complete mastery on those outcomes without sacrificing established curriculum. The study also suggests that some of the positive aspects associated with mastery learning, including a strong feedback component, may also be obtained, though there was evidence that the negative effect associated with mastery learning–higher dropout rates–may also occur with such an approach. The Focus Intervention offers an alternative approach toward the goal of assisting students to better understand and internalize mathematics necessary for course and program success.

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Instructors can select a small subset of high-priority learning objectives and expect complete mastery... without sacrificing established curriculum.

Appendix A
Focal Point Test

Pre-Algebra Focal Point Test Version 1

Remember that this is an all or nothing test (100 points or 0 points). I am testing for mastery; therefore, no partial credit. Work will be assessed according to the scoring rubric given in class. Assessment includes: math communication, use of notation, clarity of explanations, solution strategy chosen, and correctness.

1. **Simplify.**

   (-7)2 + 2 [-32 − (3 − 11)]

2. **Solve the equation. Answer with an integer or a simplified fraction.**

   -8x − 3(5 − x) = 1 + 2 (3x − 5)

3. **Evaluate and simplify.**

   (-9z)(-6x + yz) for x = -2, y = 3, and z = -4

4. **Clearly identify the meaning of your variable, write an equation that represents the problem, solve the equation, and clearly state the solution in English.**

   A high school graduating class is made up of 435 students. There are 101 more girls than boys. How many boys are in the class?

5. **Consider the items labeled A and B below and answer all three parts to this question (labeled i., ii, and iii.).**

   i. Notice that A and B have the same LCD. What is it?
   ii. In your own words, explain at least two differences between A and B.
   iii. Find an appropriate answer to both A and B showing all work.

Appendix B
Rubric for FPT Feedback

Scoring Rubric

To receive the score on the left, your work must demonstrate the characteristics on the right.

4 Advanced application of basic skills.

3 Barely proficient application of basic skills.

2 Development toward proficient application of basic skills.

1 Minimal development of basic skills.