Fall 2011

A Summary of the Effectiveness of Two Strategies for Improving Community College Mathematics Instruction: Achieving the Dream Initiatives Undertaken by the Mathematics Program at Johnson County Community College

Jeff R. Frost
Johnson County Community College, jeffrfrost@gmail.com

A Summary of the Effectiveness of Two Strategies for Improving Community College Mathematics Instruction

Achieving the Dream Initiatives undertaken by the Mathematics Program at Johnson County Community College

Fall 2011

Sabbatical Project by Jeff R. Frost

Table of Contents

Introduction....4

Figure 1: Independent and Dependent Variables....5

Figure 2: Statistical Tests....6

Part One: Accelerated Review Courses (ARCs)....7

Table 1: Days Persisted for ARCs....9

Table 2: Two Sample *t* Test for Persistence for ARCs....9

Table 3: Drops and Successes for ARCs....11

Table 4: *z* test for Successful Completion for ARCs....12

Table 5: Change in Attitude for ARCs....13

Table 6: Paired *t* test for Change in Attitude for ARCs....14

Summary of ARCs....15

Part Two: Peer-Led Supplemental Project-based (PSPI) Sessions....16

Table 7: Format of Participating PSPI Classes....17

Table 8: Twentieth Day Enrollment of PSPI Classes....18

Table 9: Course Listing of One PSPI Section....20

Figure 3: Note of Additional Information for PSPI Section....20

Table 10: Aggregate Persistence Data for PSPI....22

Table 11: Persistence Data for PSPI by Instructor....23

Table 12: *t* test for Persistence (Aggregate Data) for PSPI....24

Table 13: *t* test for Persistence (Disaggregated Data) for PSPI....24

Table 14: Drops and Successes by Instructor for PSPI....25

Figure 4: Histogram of Final Grades for Experimental Classes for PSPI....26

Figure 5: Histogram of Final Grades for Control Classes for PSPI.......................26

Table 15: *z* test for Successful Completion (Aggregate Data) for PSPI...............27

Table 16: *z* test for Student Successful Completion by Instructor for PSPI.........27

Table 17: Core Question Analysis (CQA) Data for Spring PSPI.........................29

Table 18: *z* test for CQA (Aggregate Data) for PSPI...29

Table 19: *z* test for CQA (Disaggregated Data) for PSPI....................................30

Table 20: Mean Attitudinal Data for PSPI Control Classes 31

Table 21: Mean Attitudinal Data for PSPI Experimental Classes........................32

Table 22: Paired *t* test for Changes in Attitude for PSPI Control Classes...........33

Table 23: Paired *t* test for Changes in Attitude for PSPI Experimental Classes...34

Table 24: Mean Change in Attitude by Instructor for Prompts 1, 2, and 7 35

Table 25: Results of Two Sample *t* test for Prompts 1, 2, and 7 36

Table 26: Thematic Categories for Interviews and Postings for PSPI.................38

Summary and Conclusions 46

References...48

Appendix A: Attitude Survey 50

Appendix B: Interview Questions...52

Introduction

In 2009, Johnson County Community College (JCCC) was selected to participate in the nascent Achieving the Dream (AtD) initiative. As part of that participation, the college was expected to identify significant barriers keeping their students from completing degrees and certificates. After analyzing student completion data among JCCC mathematics students, the college determined that two high-risk groups were: 1) students placing into developmental mathematics courses and; 2) students enrolled in College Algebra, the so-called gateway mathematics course at the college. In an attempt to improve success rates among those two groups of students, the mathematics division at JCCC created two initiatives—one initiative designed to improve success rates of students in developmental mathematics courses and the other initiative designed to improve success rates of students in College Algebra. This report presents an analysis of the effectiveness of:

- Accelerated Review Classes (ARCs) for students testing into developmental mathematics and
- Peer-Led Supplemental Project-Based Instruction (PSPI) sessions for students enrolled in College Algebra classes at JCCC.

Data from students enrolled during the fall 2010 or spring 2011 semester were examined. The results of quantitative data analysis on persistence, success, understanding of key course concepts, and attitude toward mathematics, along with the results of qualitative data analysis on student, tutor, and instructor perceptions of the effectiveness of these initiatives are presented in this report. Figure 1 provides a visual representation of the independent and dependent variables addressed by this research.

Independent Variables

Two-week intensive review sessions followed by additional placement procedures and enrollment in a traditional class;

Supplemental mathematical projects facilitated by peer-tutors coupled with a traditional class

Dependent Variables

Persistence (Quantitative)

Successful course completion (Quantitative)

Performance on final exam (Quantitative)

Attitude toward mathematics (Quantitative)

Student, tutor, and instructor perceptions of effectiveness of initiatives (Qualitative)

Figure 1. Independent and Dependent Variables

Several statistical analyses, determining the strength of the relationships of the independent and dependent quantitative variables, were performed. For ARCs, each instructor's experimental (i.e. ARC) was compared to his or her control (i.e. non-ARC) to test for significant differences. For PSPI classes, aggregate experimental classes were compared to aggregate control sections. Next, where applicable, each instructor's experimental section was compared to his or her control section to test for significant differences. A value of $p < 0.05$ was used to determine any significant differences that occurred. Figure 2 provides a summary of the quantitative tests used for this report.

Dependent Variable Studied	**Statistical Test**
Persistence	non-pooled *t* test for two population means
Successful course completion	*z* test for two population proportions
Performance on final exam	*z* test for two population proportions
Change in attitude toward math	paired *t* test for two population means

Figure 2. Statistical Tests Used in the Report.

Part One: The Effectiveness of Accelerated Review Courses (ARCs) on Student Achievement and Attitude toward Mathematics

While the past thirty years has seen numerous pedagogical and curriculum revision in the field of mathematics (Boaler, 1998; Arendale, 2000; Gosser, et al., 2001), challenges to improving mathematics teaching at the community college level continue to be exacerbated by a preponderance of entering students who are not ready for college-level work (American College Testing, 2006). Recently, the Carnegie Foundation for the Advancement of Teaching (2010) released a report stating, "up to 60 percent of community college students who take the placement exam learn they must take at least one remedial course to build their basic academic skills" (para. 1). Although JCCC enjoys the benefit of being located in a county with award winning elementary and secondary schools (Blue Valley School District, 2011; Olathe Public Schools, 2011), the college still experiences a large number of students who arrive at the college unprepared for college-level mathematics. Some of these students may actually be prepared for college-level math but do not spend sufficient preparing for or taking the placement exam; thus, their placement scores may not reflect their true knowledge of mathematics.

In an attempt to properly place these students into math classes (and to potentially save these students time and money), three instructors in the mathematics division, Nancy Carpenter, Rhonda Barlow, and Jennifer Kennett, designed an Accelerated Review Course. The course began with a two-week personalized intensive review; students would spend the first two weeks reviewing topics in math, trying to move into a course for which those students did not initially place. At the end of the two weeks, the three instructors met to discuss the progress the students made and to determine if a re-placement was warranted. In order to enroll in one of the ARCs, students needed special permission, which they obtained from the dean's office.

For the spring 2011 semester, 10 students who would not have been qualified to enroll in College Algebra successfully completed that course because of their work and commitment during the 2-week review and the subsequent class. Five students who would not have been qualified to enroll in Intermediate Algebra successfully completed that course because of their work and commitment. Those 15 students saved a combined $3,375 in tuition by being able to leap past one math class. While those results provide reasons to be optimistic about this initiative, it is important to determine the effect this strategy may have had on all students in the class. Thus, data from the entire class were analyzed to determine the effectiveness of an accelerated strategy in algebra.

Research question one. *To what extent do students in ARCs persist longer, achieve greater success in completing the course, or experience improved attitudes toward mathematics?*

Persistence. To measure persistence, the mean of the last date attended for students in one of the ARC classes was compared to students in that same instructor's non-ARC class. Descriptive statistics showing the number of students in the class, the mean, standard deviation, and minimum and maximums for the persistence data are presented in Table 1 below.

Table 1

Descriptive Statistics for Number of Days Students Persisted by Instructor for ARCs

Instructor	Class Type	*N*	*Min*	*Max*	*M*	*SD*
A	Experimental	24	84	140	135.5	14.0
	Control	25	71	140	129.3	22.3
B	Experimental	15	101	140	133.4	13.6
	Control	25	68	140	127.1	24.2
C	Experimental	26	49	140	126.1	29.2
	Control	22	25	140	131.6	28.5
D	Experimental	32	42	140	121.6	34.5
	Control	25	33	140	119.9	35.6

Next, a non-pooled *t* test (Weiss, 2010) was performed to determine if students in any instructors' ARC class persisted longer than students in that same instructor's non-ARC class did. The result of that analysis are presented in Table 2 below.

Table 2

Results of Two-Sample t Test for Last Date Attended Disaggregated by Instructor for ARCs

Last Date Attended	*t*	*df*	*p*	Mean Diff.
Instructor A	1.16	40	0.255	6.22
Instructor B	1.09	41	0.284	6.33
Instructor C	-0.66	46	0.512	-5.56
Instructor D	0.18	59	0.855	1.66

While students in ARCs generally persisted longer, the results of the analysis revealed no significant differences in the number of days students persisted. However, the fact that all four instructors showed no significant differences is noteworthy given the fact that not all students in the class were technically eligible to be in that class.

Success. For each of the four participating instructors, the percentage of successful students who enrolled in one of the ARCs was compared to the percentage of successful students who did not enroll in that same instructor's non-ARC. Successful completion of the course, as defined by the JCCC Math division (Wilson, 2008) and the Achieving the Dream (AtD) initiative (Achieving the Dream, 2010), means the student earned at least a C in the course. Table 3 presents descriptive statistics on the number students who successfully completed the course along with the number of students who chose to drop the course for students in the ARCs and students in that same instructor's non-ARC class, disaggregated by instructor.

Table 3

Frequencies of Student Drops and Successes for ARCs and non-ARCs

Instructor	Class Type	*N*	# Dropped	# Successful	% Successful
A	ARC	24	2	16	66.7
	Non-ARC	25	4	19	76.0
B	ARC	15	2	10	66.7
	Non-ARC	25	4	17	68.0
C	ARC	24	5	15	62.5
	Non-ARC	22	1	19	86.4
D	ARC	32	2	16	50.0
	Non-ARC	30	2	16	53.3

Next, using a *z* test for population proportions, a hypothesis test was conducted to determine if students in any instructor's ARC course had a significantly different completion rate than students in that same instructor's control class did. The results of that analysis are presented in Table 4.

Table 4

Results of z Test for Successful Completion by Instructor for ARCs

Successful Completion	*z*	*p*	Difference
Instructor A	-0.73	0.468	-0.09
Instructor B	-0.09	0.931	-0.01
Instructor C	-1.94	0.052	-0.24
Instructor D	-0.26	0.793	-0.03

In all four classes, the success rate for the control class exceeded the rate of students in that same instructor's ARC. In fact, the difference for students in Instructor Cs class was nearly significant ($p = 0.052$). In the other cases, the difference was not significant. The fact that three of the four classes showed no significant difference in student success rates is noteworthy because not all students in the class were technically eligible to be in that particular class and because the actual class was conducted over a 14-week period (instead of the usual 16 weeks).

Finally, student perceptions of learning mathematics were measured using an attitudinal survey developed at Kansas State University (Manspeaker, 2010). Participating instructors administered the survey during the first week of class and again near the end of the class. Attitudinal data were only available for students in one of the ARC courses and not the control classes. Table 5 below provides summary information for the mean ratings of the 10 attitudinal prompts, disaggregated by instructor. In this table, Q1 refers to the first prompt, Q2 to the second prompt, and so on. Students ranked each prompt using a Likert scale with 1 = strongly disagree up to 5 = strongly agree. Students were assigned a numerical code to protect the anonymity of their answers; the researcher (alone) collected and compiled student responses. The survey is included in Appendix A.

Table 5

Mean Attitudinal Data for Students in ARC Classes

Instructor		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
A	Pre	3.94	3.33	2.50	4.17	4.78	3.06	3.72	4.12	3.56	4.00
	Post	3.67	2.67*	2.39	4.06	4.50	2.67	3.83	3.83	3.22	3.94
B	Pre	3.73	3.45	3.09	4.00	4.82	3.27	2.91	3.64	3.73	3.09
	Post	3.64	3.27	3.45	4.36	4.36	3.00	3.09	3.55	3.73	3.18
C	Pre	3.23	3.31	2.92	4.15	4.38	3.00	3.15	3.15	3.46	3.46
	Post	3.77	2.69	3.00	4.46	4.46	3.23	3.38	3.23	3.62	3.38
D	Pre	3.31	4.44	3.13	4.31	4.50	3.31	3.50	3.50	4.25	3.69
	Post	4.06*	3.13*	3.00	4.50	4.56	3.50	3.44	3.63	3.94	3.50

Note: *Indicates significant difference pre- to post

As noted in Table 5 above, significant changes from pre- to post- occurred on prompt 1 (Instructor D) and prompt 2 (Instructors A and D). However, relatively large differences also occurred on prompt 1 (Instructor C), prompt 2 (Instructor C), prompt 4 (Instructors B and C), and prompt 5 (Instructor B). Table 6, shown below, summarizes the most significant results of the paired *t* tests performed on the differences in prompts pre- to post.

Table 6

Results of Paired t Test for Change in Attitude on Questions 1, 2, 4, and 5

Change in Attitude	*N*	*t*	*p*	95% CI for Mean Diff.
Instructor A				
Q2	18	-2.49	0.024*	(0.10, 1.23)
Instructor B				
Q4	11	1.79	0.104	(-0.09, 0.082)
Q5	11	1.84	0.096	(-1.01, 0.10)
Instructor C				
Q1	13	2.01	0.068	(-0.05, 1.12)
Q2	13	-1.86	0.088	(-1.34, 0.11)
Q4	13	1.76	0.104	(-0.07, 0.69)
Instructor D				
Q1	16	3.22	0.006*	(0.25, 1.25)
Q2	16	-5.18	0.000*	(-1.85, -0.77)

Note: * Indicates significant change at $p < 0.05$

An analysis of the attitudinal data showed a large (and in the case of two instructors, significant) difference on the second prompt: mathematics in a worthwhile subject to learn. The mean score for Q2 decreased for students participating in one of the ARCs. Those students seemed to experience a negative change in attitude toward their belief that learning mathematics was worthwhile. With specific exceptions noted above, differences pre- to post- were not significant on any other prompts.

Summary of ARCs. Although the relatively small number of student participants compromises the statistical significance, a preliminary analysis of these data provides evidence that an accelerated review strategy may be beneficial to some students. Furthermore, analysis of completion data indicated that the format of the ARCs (i.e., two-week intensive review followed by a late-start class) had no significant negative effect on persistence or success. Finally, these data indicated that student perceptions of whether math was worthwhile to learn decreased significantly for students participating in one of the ARCs. More research is recommended to determine why that negative change in attitude may have occurred.

Part Two: The Effectiveness of Peer-Led Supplemental Project-Based (PSPI) Instruction Sessions on Student Achievement and Attitude toward Mathematics

The second initiative implemented by the JCCC math division was one that combined a traditional College Algebra classroom with peer-led supplemental project-based instruction sessions. The project sessions, led by peer-tutors, met weekly; students in one of the PSPI classes were required to attend the supplemental sessions. While JCCC offers College Algebra in a variety of teaching modalities—both in a face-to-face format and through distance learning—students in distance learning (online) classes did not take part in PSPI classes because of the required supplemental instruction sessions. The college offers face-to-face College Algebra classes in a one-day-a-week format, two-day-a-week format, three-day-a-week format, or a five-day-a-week slow-paced format. From all possible instructors teaching multiple sections of College Algebra in the same format (N = 10), two instructors volunteered to participate in the study during fall 2010; three instructors volunteered to participate in the spring of 2011. Table 7 below describes the format of the classes included in the initiative.

Table 7

Format of Participating PSPI Classes

Instructor	Semester	Number of Weekly Meetings
A	Fall 2010	3
B	Fall 2010	2
C	Spring 2011	5
D	Spring 2011	2
E	Spring 2011	3

In the fall of 2010, three mathematics instructors, Bill Robinson, Steve Wilson, and Jeff Frost, designed materials and activities for the supplemental sessions. After that initial semester, with input from the participating tutors and from an additional math instructor, Kathleen Lefert, the materials were revised. Those revised materials were used during the spring 2011 semester. In all, five instructors volunteered to participate in this initiative during the fall 2010 or spring 2011 semester; each instructor taught two sections of College Algebra during the same semester in the same format. Once identified, those instructors selected one section as experimental, which included peer-led supplemental project-based sessions, and the other class as a control group, which did not include peer-led supplemental project-based sessions. The experimental classes taught in a two-day-a-week format or a three-day-a-week format (Instructors A, B, D, and E) had an additional hour of class scheduled. Students enrolling for one of those experimental classes knew they were committing to an additional hour of instruction. The experimental class taught in a five-day-a-week format (Instructor C) did not include an extra hour of instruction; for that class only, supplemental projects were nested within the course material.

Students. All College Algebra classes chosen for participation in the study required no special permission for enrollment. Therefore, students self-selected either one of the experimental classes or one of the control classes. All classes chosen for study had a maximum enrollment of 30 students. Table 8, shown below, gives class sizes on the twentieth day of class for each of the experimental and control classes participating in the study.

Table 8

Twentieth Day Class Sizes of Participating PSPI Classes

Section	**Semester**	**20th Day Class Size**
Experimental A	Fall 2010	25
Control A	Fall 2010	25
Experimental B	Fall 2010	24
Control B	Fall 2010	28
Experimental C	Spring 2011	26
Control C	Spring 2011	22
Experimental D	Spring 2011	22
Control D	Spring 2011	25
Experimental E	Spring 2011	19
Control E	Spring 2011	27

In addition to gathering and analyzing quantitative data, qualitative data from a small subset of students taking part in the initiative was also gathered. Unlike the relatively large stratified sample chosen for the quantitative portion of the study, the subsample for the qualitative portion was smaller and more purposefully selected. As Creswell (2009) explains, "the idea behind qualitative research is to **purposefully select** (author's emphasis) participants or sites that will best help the researcher understand the problem and the research question" (p. 178). A purposive sample of students (n = 3) from different demographic backgrounds agreed to take part in interviews; two successfully completed College Algebra and one did not successfully complete.

Tutors. Two purposively selected peer tutors from those employed in the Math Resource Center (MRC) facilitated the supplemental sessions. In addition to serving as project session facilitators, the tutors chosen to participate in the study worked approximately 20 hours a week in the MRC. The tutor and instructor met prior to the beginning of the semester to foster a positive working relationship.

Supplemental sessions and materials. Materials for the supplemental sessions were created using a combination of cooperative learning strategies, which included components of project-based mathematics (Boaler, 1998), Supplemental Instruction (Arendale, 2000), learning communities (MacGregor, 1994; Tinto, 1998; Day & Frost, 2009), and Peer-Led Team Learning (Gosser, D., et al., 2001). Students in one of the experimental College Algebra classes met an additional hour each week to work on structured projects. Students who opted for one of the experimental classes knew they were signing up for this additional hour of class. Table 9 below shows the way in which one experimental class appeared on the college's website.

Table 9

Course Listing of One Experimental PSPI Section

Division	Course	Section	Days	Time	Classroom
Math	171	009	MWF	10:00-10:50A	CLB 316
Math	171	009	M	11:00-11:50A	CC 319

Note. From Johnson County Community College Credit Course Schedule, 2010.

In addition to the extra hour shown on the college's credit class website, each experimental section listing included a note giving students additional information about why the extra hour of instruction was necessary. Figure 3 below shows an example of that note.

Note: Math 171-009, the section listed above, uses supplemental projects to enhance what is learned in the traditional classroom. Students who choose this section will learn the topics through additional activities that have been designed by the instructor for the course. Students are required to attend the extra sessions and take part in the additional activities. These course enhancements are part of the Achieving the Dream Initiative at JCCC.

Figure 3. Note of additional information for experimental sections. From Johnson County Community College, 2010.

The supplemental sessions employed a modified version of the University of Missouri–Kansas City (UMKC) Supplemental Instruction (SI) model (Arendale, 2000). One peer tutor facilitated each experimental section; the peer tutor attended each class session held by the instructor, regardless of the number of class meetings. The peer tutor led the weekly supplemental project sessions, guiding the students through the materials prepared by the instructors. The instructor did not attend the weekly supplemental sessions. Unlike the UMKC SI model, which does not require student attendance at the SI sessions, the students in this study were required to attend supplemental sessions and the work completed in those sessions counted toward the students' final grades. The peer tutors met weekly with the instructor, providing feedback about the challenges or successes of the projects. JCCC offers full-semester classes in a 16-week format; the supplemental sessions lasted 12 weeks, beginning the second week of class and ending approximately three weeks before the end of the term. Students did not pay for the supplemental sessions.

In the supplemental sessions, the tutor organized students into small discussion groups; each group had approximately four students. In the spring of 2010, the researcher, working with the two instructors who would be participating in the fall, designed materials for the supplemental sessions. In May and June 2010, the two instructors who participated in the fall study worked collaboratively with the researcher to design materials for their supplemental project sessions. After the fall 2010 semester, the researcher interviewed the tutors in order to gather feedback about the effectiveness of the materials used in the supplemental sessions. The instructors participating in the spring 2011 study worked with the researcher in January 2011 to revise the project-session materials, making use of feedback gathered from tutors and students who had taken part in fall 2010.

The supplemental sessions included activities based on four College Algebra concepts: 1) the meaning of a function; 2) the characteristics of polynomials; 3) examples of exponential growth or decay; 4) sequences and series or systems of equations. Beyond College Algebra concepts, the sessions addressed twenty-first century learning outcomes (Wagner, 2008), including critical thinking and problem-solving, effective oral and written communication, and collaboration. Each of the four activities spanned three weeks of work. Part one, an introduction to the topic, allowed the students to work together to discover characteristics of the topic. In week two of each activity, students worked together to solve the problem woven throughout the topic. Students presented their findings to other session attendees and to the tutor during week three. The students repeated this pattern for each of the four activities.

Research question two: *To what extent do peer-led supplemental project-based instruction sessions increase the average number of days students persist, the percentage of students who successfully complete, and the level of understanding of mathematical concepts?* Table 10 provides descriptive statistics for the mean number of days students persisted in the experimental and control sections.

Table 10

Descriptive Statistics for Number of Days Students Persisted (Aggregate Data) for PSPI

Class Type	*N*	*Min*	*Max*	*M*	*SD*
Experimental	116	48	140	125.7	24.7
Control	127	26	140	127.4	26.2

Next, the persistence data were disaggregated by instructor. Those data are presented in Table 11 below.

Table 11

Descriptive Statistics for Number of Days Students Persisted by Instructor

Instructor	Class Type	*N*	*Min*	*Max*	*M*	*SD*
A	Experimental	25	70	140	131.5	18.5
	Control	25	88	140	134.8	13.9
B	Experimental	24	48	140	118.3	32.5
	Control	28	50	140	127.0	25.2
C	Experimental	26	68	140	127.3	22.8
	Control	22	26	140	122.1	36.6
D	Experimental	22	73	140	124.9	21.4
	Control	25	52	140	124.1	29.3
E	Experimental	19	52	140	125.9	26.7
	Control	27	67	140	128.2	22.8

Using a *t* test for independent samples, the mean number of days persisted for the aggregated experimental classes was compared to the mean number of days persisted for the aggregated control classes to see if students in the experimental classes persisted longer. The results of that hypothesis test are presented in table 12 below.

Table 12

Results of Aggregated Two-Sample t Test for Persistence (Aggregate Data)

No. of Days Persisted	*N*	*t*	*df*	*p*	Mean Diff.
All Control vs. Exp.	243	-0.52	240	0.699	-1.72

Next, the data were disaggregated by instructor, and a non-pooled *t* test for two independent samples (Weiss, 2010) was performed to determine whether students in the experimental class persisted longer than students in that same instructor's control class. In this case, the non-pooled *t* test was appropriate because of the relatively large differences in standard deviation between the control classes and experimental classes when disaggregated by instructor (see table 6). The results of the non-pooled *t* tests are presented in table 13.

Table 13

Results of Two-Sample t Test for Last Date Attended Disaggregated by Instructor

Last Date Attended	*N*	*t*	*df*	*p*	Mean Diff.
Instructor A	50	-0.7	44	0.756	-3.24
Instructor B	52	-1.06	43	0.853	-8.67
Instructor C	48	0.57	34	0.285	5.17
Instructor D	47	0.11	43	0.458	0.78
Instructor E	46	-0.31	34	0.620	-2.33

The results of the first *t* test indicated that students in the aggregated control classes persisted slightly longer on average than students in the experimental classes; however, the difference was not statistically significant ($p = 1 – 0.699 = 0.301$). The results of the disaggregated data analyses revealed students in an experimental class did not persist statistically significantly longer than students in that same instructor's control class, regardless of the instructor.

Using the same definition of "success" presented earlier in this report, data on the percentage of drops and successes from experimental and control classes were analyzed. Table 14 presents the number of successful students by instructor and section as well as the number of students who chose to drop the course.

Table 14

Frequencies of Student Drops and Successes by Instructor for PSPI

Instructor	Class Type	*N*	# Dropped	# Successful
A	Experimental	25	5	15
	Control	25	4	16
B	Experimental	24	9	8
	Control	28	7	19
C	Experimental	26	7	13
	Control	22	5	12
D	Experimental	22	8	11
	Control	25	7	15
E	Experimental	19	5	11
	Control	27	7	13

Figure 4 (shown below) provides a histogram of the distribution of final grades for the aggregate experimental classes; a relatively large number of students did not succeed despite the required supplemental sessions.

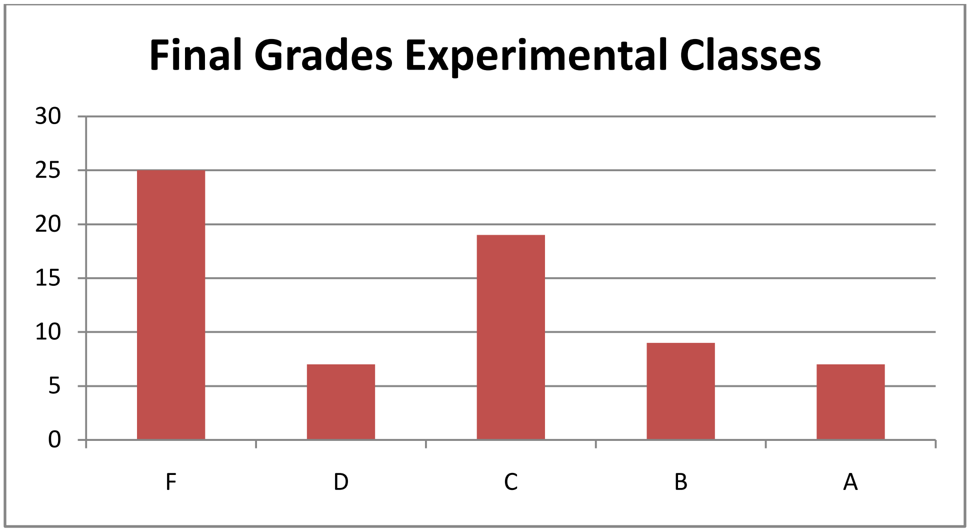

Figure 4. Histogram of Final Grades of Experimental Classes

Figure 5 provides a histogram of the distribution of final grades for the aggregate control classes. Although more students earned B grades than counterparts in experimental classes, the distribution of grades was similar to the distribution of grades in the experimental classes.

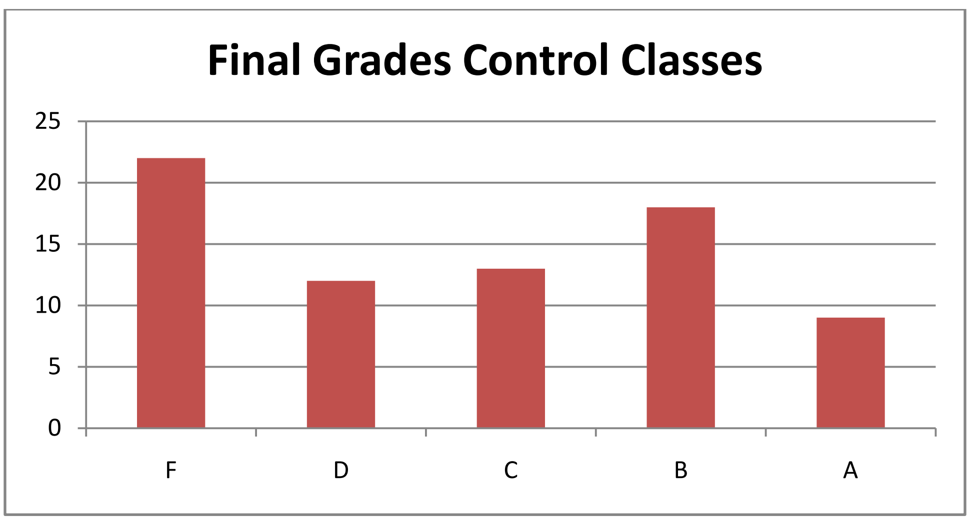

Figure 5. Histogram of Final Grades of Control Classes

To test research hypothesis 2, a *z* test for two population proportions was performed to determine if the proportion of successful completers in the aggregated experimental classes (58 out of 116 = 50%) exceeded the proportion of successful completers in the aggregated control classes (75 out of 127 = 59%). Table 15 provides the results of that hypothesis test.

Table 15

Results of Aggregated z Test for Successful Completion

Successful Completion	*N*	*z*	*p*	Difference
All Control vs. Exp.	243	-1.42	0.922	-0.09

Next, the data were disaggregated by instructor, and a *z* test for two population proportions was performed to determine if students in one of the experimental classes were more successful than students in that same instructor's control class. The results of that hypothesis test are presented in table 16.

Table 16

Results of z Test for Successful Completion by Instructor

Successful Completion	*N*	*z*	*p*	Difference
Instructor A	50	-0.29	0.615	-0.04
Instructor B	52	-2.64	0.996	-0.35
Instructor C	48	-0.31	0.623	-0.05
Instructor D	47	-0.69	0.755	-0.10
Instructor E	46	0.66	0.256	0.10

The results of the *z* tests indicated that students in the control classes tended to be more successful than students in the experimental classes were. In fact, in the class taught by instructor B, students in the control class were significantly more successful; no other instructor's class showed a significant increase in success when comparing the experimental class against the control class.

Successful understanding of course concepts was determined through use of a Core Question Analysis (CQA) on the final exams. The math division at JCCC implemented the requirement of administering common final exams in 1990 (Wilson, 2008). The course content coordinators (so called c-cubed instructors) wrote Core Questions, which are final exam questions that correspond directly to course outcomes. For example, one of the outcomes of College Algebra is to “Apply exponential and logarithmic equations to problems, e.g., growth and decay” (Johnson County Community College, 2011d). The c-cubed instructors for College Algebra wrote Core Question 18 on the departmental final exam to test that outcome. An outline of the Core Questions for College Algebra appears in the Appendix.

After the spring 2011 semester, the mathematics division analyzed final exams of students in the experimental group (supplemental projects) and the control group (students in that same instructor’s traditional class). For each student’s final exam, the number of the ten Core Questions answered correctly (C) and the number of Core Questions on which the student made an error (E) were recorded. The percentage of students in the experimental who answered the Core Questions correctly were compared to those in the control class.

The results of the descriptive statistics of the Core Question Analysis (CQA) for spring 2011 cohorts are presented below; final exam data for fall 2010 were not available for analysis. Table 17 provides information by class on the percentage of the ten questions students answered correctly.

Table 17

Descriptive Statistics of PSPI Core Question Analysis (CQA) for Spring 2011

Instructor	Class Type	N	%Correct
C	Experimental	19	50.0
	Control	17	52.3
D	Experimental	14	38.6
	Control	18	47.7
E	Experimental	14	45.7
	Control	20	46.5

Using a *z* test for two population proportions, analysis of CQA data was performed to determine whether students in the experimental classes answered a larger percentage of core questions correctly than students in the control classes did. The results of that hypothesis test are presented in Table 18 below.

Table 18

Results of Aggregated z-test for Core Question Analysis

Correct Core Questions	*N*	*z*	*p*	Mean Diff.
All Control vs. Exp.	102	-1.09	0.862	-0.03

Next, data were disaggregated by instructor and a *z* test for two population proportions was performed to determine if students in an experimental class answered a larger percentage of Core Questions correctly than students in that same instructor's control class did. Table 19 provides the results of that inferential analysis.

Table 19

Results of z Test for PSPI Core Question Analysis by Instructor for Spring 2011

CQA	*N*	*z*	*p*	Mean Diff.
Instructor C	36	-0.45	0.672	-0.02
Instructor D	32	-1.66	0.961	-0.92
Instructor E	34	-0.14	0.557	-0.10

The results of these *z* tests indicated that students in the aggregated control classes showed a higher level of understanding of course concepts than students in the aggregated experimental classes. When the Core Questions were disaggregated by instructor, all three instructors had higher levels of conceptual understanding in their control classes than in their experimental classes. In fact, in Instructor D's class, students in the control class scored significantly higher when compared to students in Instructor D's experimental class.

Research question 3. To what extent do peer-led supplemental project-based instruction sessions change the attitudes toward mathematics of students in a College Algebra class at a community college? Using an attitudinal survey (see Appendix), students rated their perceptions of learning mathematics. Table 20 provides mean ratings for each of the ten attitudinal prompts for control classes, from the beginning of the semester (pre) until the end of the semester (post).

Table 20

Mean Ratings on Attitudinal Survey Prompts by Instructor for Control Classes for PSPI

Instructor		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
A	Pre	3.79	3.39	2.82	4.11	4.43	3.11	3.93	3.79	3.75	3.86
	Post	4.00	3.32	2.77	4.45	4.64	2.91	3.77	3.82	3.91	3.77
B	Pre	3.31	3.38	2.76	4.21	4.66	2.90	3.21	3.38	3.34	3.48
	Post	3.52	2.81	2.81	4.29	4.43	2.76	3.62	3.71	3.67	3.67
C	Pre	3.77	4.41	2.68	4.14	4.55	3.27	3.55	3.27	3.36	3.41
	Post	3.47	3.47	2.47	4.53	4.67	3.67	4.13	3.21	3.73	3.67
D	Pre	3.70	4.20	3.00	4.00	4.80	3.00	3.57	3.17	3.53	3.50
	Post	3.53	3.18	3.41	4.71	4.53	3.65	3.65	3.59	3.59	3.24
E	Pre	3.96	4.54	2.81	4.04	4.58	3.19	3.85	3.92	3.73	3.92
	Post	4.00	2.74	2.84	4.16	4.74	2.68	3.89	4.42	4.16	4.16

Table 21 provides mean ratings for each of the ten attitudinal prompts for the experimental classes.

Table 21

Mean Ratings on Attitudinal Survey Prompts by Instructor for Experimental Classes

Instructor		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
A	Pre	4.03	3.59	2.79	4.10	4.52	3.52	3.55	3.69	3.55	3.93
	Post	3.85	3.20	2.80	4.45	4.50	3.20	3.50	4.21	4.15	4.05
B	Pre	4.00	3.65	2.91	4.35	4.43	3.13	3.96	3.65	3.52	3.61
	Post	3.53	2.80	3.27	4.13	4.53	3.07	3.00	3.20	3.07	3.47
C	Pre	3.57	4.07	3.11	4.57	4.54	3.32	3.32	3.21	3.04	3.25
	Post	3.06	3.18	3.22	4.78	4.56	3.89	3.17	2.50	2.78	3.11
D	Pre	4.12	4.12	3.04	4.36	4.68	3.56	3.76	3.12	3.12	3.40
	Post	4.00	3.50	4.00	4.36	4.64	4.07	3.71	3.64	3.86	3.86
E	Pre	4.05	4.16	2.95	4.42	4.53	3.68	3.42	2.89	2.95	3.05
	Post	4.07	3.29	2.85	4.29	4.93	3.43	3.50	3.64	3.64	3.62

To determine if there was a significant difference in the mean for any of the attitudinal prompts in the control classes, paired *t* tests were utilized. The results of those tests are shown in Table 22 below.

Table 22

Results of Paired t-Tests of Mean Attitudinal Difference for Aggregate PSPI Control Classes

Attitude: Ctrl. Pre to Post	*N*	*t*	*p*	95% CI LL*	95% CI UL*
Question 1	93	0.64	0.525	-0.136	0.265
Question 2	93	-7.13	0.000	-1.210	-0.683
Question 3	93	0.49	0.624	-0.196	0.325
Question 4	93	2.78	0.007	0.083	0.498
Question 5	93	-0.48	0.630	-0.220	0.134
Question 6	93	0.81	0.420	-0.156	0.371
Question 7	93	0.72	0.475	-0.152	0.324
Question 8	92	0.93	0.353	-0.111	0.306
Question 9	93	1.12	0.267	-0.101	0.359
Question 10	93	0.09	0.925	-0.215	0.237

*A 95% confidence interval with LL= lower limit and UL=upper limit

The results for a paired *t* test to determine if any of the attitudinal prompts differed significantly from pre- to post- for the aggregate experimental classes are presented in table 23 below.

Table 23

Results of t-Test of Mean Attitudinal Difference for PSPI Experimental Classes

Attitude: Exp. Pre to Post	*N*	*t*	*p*	95% CI LL*	95% CI UL*
Question 1	80	-2.57	0.012	-0.554	-0.071
Question 2	80	-4.33	0.000	-0.967	-0.358
Question 3	80	1.78	0.079	-0.028	0.503
Question 4	81	0.59	0.559	-0.118	0.217
Question 5	81	0.91	0.365	-0.103	0.275
Question 6	81	0.55	0.584	-0.194	0.342
Question 7	81	-2.37	0.020	-0.545	-0.048
Question 8	80	0.31	0.755	-0.201	0.276
Question 9	81	0.27	0.709	-0.239	0.313
Question 10	79	1.66	0.100	-0.037	0.417

*A 95% confidence interval with LL= lower limit and UL=upper limit

The results of the *t* tests indicated statistically significant changes in attitude for the control classes on questions 2 (Mathematics is a worthwhile subject to learn) and 4 (It is very important to me that I attend a small class where the instructor can keep track of my progress). Significant differences in attitude were present in the experimental classes on questions 1 (I believe I can learn mathematics through group projects), 2 (Mathematics is a worthwhile subject to learn), and 7 (I anticipate using math in my future career).

Based on the results, further analysis was warranted for questions 1, 2, and 7; question 4 only showed a significant change for control classes and was therefore not examined further. In order to isolate the effect of the supplemental sessions on the change in attitude (and not teacher or other effect), each instructor's experimental class was compared to that same instructor's control class for statistically significant change in attitude on questions 1, 2 and 7. Those data are presented in table 24.

Table 24

Mean Change in Attitude for Questions 1, 2, and 7 by Instructor for PSPI

Instructor	Class Type	Change Q1	Change Q2	Change Q7
A	Control	0.14	-0.32	-0.18
	Experimental	-0.25	-0.35	-0.25
B	Control	0.52	-0.52	0.33
	Experimental	-0.50	-0.21	-0.71
C	Control	-0.36	-0.86	0.64
	Experimental	-0.44	-0.83	-0.17
D	Control	-0.35	-1.41	-0.24
	Experimental	-0.29	-0.64	-0.21
E	Control	0.22	-1.78	0.06
	Experimental	0.21	-0.71	0.29

Using the disaggregated data, a non-pooled *t* test for two independent samples was performed to compare changes in sample means of attitudinal prompts for experimental and control groups by instructor. However, it should be noted that disaggregating the data by instructor yielded relatively small sample sizes. Table 25 gives the results of those hypothesis tests.

Table 25

Results of Two-Sample t Test for Change in Attitude on Questions 1, 2, and 7

Change in Attitude	*N (Ctrl, Exp)*	*t*	*df*	*p*	Mean Difference
Instructor A					
Q1	22, 20	-1.35	39	0.184	-0.39
Q2	22, 20	-0.09	33	0.931	-0.03
Q7	22, 20	-0.18	39	0.856	-0.07
Instructor B					
Q1	21, 14	-2.69	28	0.012*	-1.02
Q2	21, 14	0.88	26	0.389	0.31
Q7	21, 14	-2.65	32	0.012*	-1.05
Instructor C					
Q1	14, 18	-0.22	26	0.828	-0.09
Q2	14, 18	0.06	29	0.955	0.02
Q7	14, 18	-2.59	29	0.015*	-0.81
Instructor D					
Q1	17, 14	0.19	27	0.853	0.07
Q2	17, 14	1.40	28	0.172	0.77
Q7	17, 14	0.06	28	0.955	0.02
Instructor E					
Q1	18, 14	-0.02	18	0.985	-0.01
Q2	18, 14	1.98	26	0.058	1.06
Q7	18, 14	0.50	17	0.622	0.23

Note: * Indicates significant change at $p < 0.05$

With the exception of Question 7 for Instructor C, there was no significant difference in the change in attitude in ratings of prompts between the control and experimental classes during the spring semester using the disaggregated data. During the fall semester, significant differences were present in Questions 1 and 7 for Instructor B; students in Instructor B’s control class rated “I believe I can learn math concepts through group projects” and “I anticipate using math in my future career” higher than cohorts in Instructor B’s experimental class did.

Research Question 4. *To what extent do peer-led supplemental project-based supplemental sessions in mathematics contribute to success for students in a community college?* In order to determine a possible connection between the project-based supplemental sessions and student success in mathematics, the researcher conducted a series of interviews with selected students, with tutors, and with participating instructors. Two instructors involved in the study during the spring posted questions online; students in their experimental classes posted responses to those questions. Comments from interviews and postings were categorized for common themes. Seven common themes emerged from this analysis: 1) success; 2) understanding; 3) fairness and complaints; 4) communication and interaction; 5) relationships and collaboration; 6) extra help; and 7) involvement. Summarized qualitative data from interviews and online postings by participant type (student, tutor, faculty), thematic category, key terms, and sample quotes, is presented in table 26.

Table 26

Thematic Categories from Interviews and Posts for PSPI Classes

Participant type	Thematic Category	Key Terms	Quotes
Student, Instructor	Success	Pass, high grade, graduate, succeed, persist, work together, tutor, lack of fear of math	"Passing with a good grade…" "I know this will be difficult but rewarding"
Student, Tutor, Instructor	Understanding	Understand, grasp, comprehend, apply, recognize, accomplish, learning styles, teaching, coaching, going beyond skills	"actually understanding algebra" "these are the types of things I would do if I had time"
Student, Tutor	Fairness/Complaints	Extra hour, more work, additional sessions	"it was an extra hour we didn't get credit for" "have we done enough to leave?"
Tutor, Instructor	Communication and Interaction	Openness, lack of fear, insights, how they felt about the class	"They are more open with the tutor than they are with me"
Student, Tutor, Instructor	Relationships and collaboration	Community, groups, meeting new people, work with friends, talking, candid, cooperation, insight, sharing, synergy,	"the most beneficial part of the supplemental sessions was getting to interact with my classmates more"
Student, Tutor	Extra Help/Special bond with tutor	Private tutor, study groups, extra study sessions	"just having some extra time with the tutor each week really helped me"
Tutor, Instructor	Involvement	Attended sessions, got into projects, asked questions, talked to each other	"there was a competitive energy – students really got excited about the learning"

Within the three homogenous subgroups (students, tutors, faculty), interviewees showed consistency in their descriptions of the seven themes. However, those descriptions did not necessarily match those of participants in other subgroups. For example, while students described success as completing the course, instructors had a broader definition. In some specific areas (such as relationships and collaboration) comments among the three subgroups were nearly identical. In other thematic areas (such as fairness, understanding, and success), the comments were noticeably different. The next section describes the major comments written or spoken by members of the three subgroups along with specific quotes.

Success. Students, tutors, and instructors used the term "success" in interviews; however, that term may have connoted different meaning to those groups. Students defined success as passing the class, getting a high grade, graduating, or learning the fundamentals to help them succeed in future math classes. For example, one student commented that it was important that he "pass with a good grade and actually understand algebra because it will be beneficial to my future career." Other students defined success as simply getting through the course. Several students, in posts and interviews, described how many times they had taken College Algebra and dropped or failed the course. For these students, success meant simply getting through the class (Student CS; Student JW). One student summarized the sessions by stating, "I could not have passed it without the help of those group sessions that we did" (Student JW).

Instructors talked about the lack of success currently occurring in College Algebra. Instructor B stated, "I saw the problems present in the current College Algebra course." Instructors spoke about trying new things in order to get more students through the class, lower the drop rates, and help students make connections between the material in the class and realworld applications. Instructor D noted, “I think sometimes they don’t see those connections between what they are doing in math and how that extends outside of the classroom.” Overall, instructors’ definition of success was broader, including the hope that beyond completing the course, students would become better mathematical thinkers. In reflecting on the overall success of the sessions, Instructor B explained:

> I think having seen a number of the students do better, in particular, it was very noticeable when we got to the end of the course when we were dealing with sequences and series. The groups who had the sessions were much more willing to investigate patterns and try things whereas the control group was still interested in looking for formulas. And that was a terrific result.

Understanding. Some students talked or wrote about the importance of understanding in order to earn a high grade, do well in the next class, or achieve a career goal. Student JM explained, “What I am looking for in this class it to completely understand the material.” Other students noted the sense of accomplishment they felt after solving one of the difficult problems presented in the sessions. Student SO remarked, “I kind of liked it because once I did come to a conclusion, it always felt really good.” Many students described “understanding” as knowing which formula to use. Tutors tended to talk about the importance of understanding because of their love of math and wanting that passion to rub off, with the possibility of creating more math enthusiasts. Tutor H noted, “I have an infectious type of enthusiasm for math and I was hoping that would kind of rub off.” Tutor H also explained how these sessions reminded him of how he needed to be more aware of differences in student learning styles. Instructors tended to talk about the need to go beyond the teaching of skills. They described the need to have students reach a higher level of understanding of the material. Instructors also talked about not having the time to do these kinds of extra activities in their classes because of the amount of material they needed to cover. As Instructor D explained, "The College Algebra curriculum is so full that it is hard to get everything done that we want to get done, and so doing some of those connections and some of those fun things, we don't really get to that very often."

Students used the word "understand" to describe one particular session activity: the session on exponential growth. For that topic, students had to research interest rates banks were currently offering in order to solve the embedded problem. Several students reported they had a better understanding of the concept of exponential growth because of this activity. Student EW described the topic this way: "I believe the group session when we were asked to do research on the college fund was the most beneficial. I found it to be truly interesting."

Fairness and complaints. Students complained to the tutor about having to spend an extra hour working on math but not getting credit for it. (The instructors involved in the study assigned points to the sessions and counted work toward the student's final grade.) Students also expressed concerns about the fact that other College Algebra students did not have to attend extra sessions while they did. (Supplemental sessions for students in the experimental classes were mandatory.) Student SC commented that, "In the beginning, we all complained about it but in the end, only a few people complained about the sessions." Student JW complained: "quite a few of us [were not happy] in the beginning when we heard we would have another hour after the class—to sit through more math. No one would want to do that unless you wanted to be a math teacher." Students who did not see an immediate positive impact on their grades in the class complained that the sessions were a waste of time. Student CS explained that she, "expected to get higher grades on my tests and when I didn't, I wondered why I bothered to go to the sessions." Tutors stated that they occasionally had to deal with negative comments from students; those ensuing discussions cut into their project time. Tutor H noted that, "there was a guy that was so negative he started rubbing off on other people. Other people finally told him to tone it down." One student explained it this way: "I am always a positive person so sometimes when other students would get real negative about something and it would just frustrate me" (Student SC). Tutors also stated that some of the projects seemed like busy-work to many of the students. One tutor explained that, "project 4 was a dud. The scale was too large" (Tutor I). Another tutor remembered that students sometimes complained that, "the projects did not pertain to anything we will be doing in the class" (Tutor H).

Communication. Several communication and interaction themes emerged within the comments of students, tutors, and instructors. Tutors and instructors, in describing the relationship between tutors and students, talked about the differences in the ways students communicated when the instructor was not present. Instructor B was particularly cogent in his explanation of those differences in communication:

> The biggest thing I learned from working with the tutor is that the tutor was very free of the negative connotations that come with being an instructor. The students were quite open with him in ways that they were not with me. I guess there is less fear of being seen negatively by the tutor. So, he had a lot more ability to relate to students, I think, than I did. I'm actually kind of envious.

The tutors shared some of the same sentiments, noting that students would often be very candid with them about their feelings toward the projects or the class. In addition, tutors and instructors noticed increased student interaction with an emphasis toward mathematical thoughts and ideas. One instructor observed more communication among students in the classroom, which he attributed to the fact that "they were together for an hour once a week talking to each other"

(Instructor E). One tutor observed that more students arrived early to class to talk with him and each other about the projects, homework, or exams (Tutor H). Instructor A commented, "I did hear one student talking about a test question who said, 'We talked about this in our groups. I did the problem right because we did this in our group.'" Another instructor remembered a posting from one student, who noted, "I didn't realize how having someone to talk about it with, what a difference that would make" (Instructor D).

Relationships and collaboration. Students often spoke or wrote about the importance of their group. Student JW wrote, "The group work helped to strengthen my understanding in how to determine end behavior, and how to plot and determine zeros." For some, the importance of the group changed throughout the semester. One student began the semester with this posting:

> I don't know how I feel about the supplemental project part of the class. I've never been big with working in groups because I like to work at a fast pace and hate waiting for the rest of the group to catch up (Student EM, February 14, 2011).

That same student wrote this posting at the end of the semester:

> The most beneficial part of the supplemental sessions for me…hmm…I would have to say learning to work in groups, although in the past it has not been my favorite thing (Student EM, April 27, 2011).

Another student wrote that, "Working with friends really did help out a lot and made me more comfortable in class" (Student AZ). Still another student commented that, "It was almost like we went to summer camp together" (Student SC). In the early days of the spring sessions, Tutor I heard students say, "We are going to be in this three-person or four-person group for the next four weeks; we need to look out for each other." Tutors not only mentioned the relationships they built with students, but also the joy of working closely with the instructor.

One tutor explained, “I am interested in becoming a professor and I thought that being involved with it would give me a chance to work more closely with the professor” (Tutor I). Another tutor, reflecting on what he learned from the instructor’s lectures, mentioned, “There’s always a billion different ways to explain something and you are taught in a certain way and that tends to stick with you. But you hear it presented in a different way and you think, ‘hey, I never thought about it like that’” (Tutor H). Tutor I described how attending class and watching the relationships instructors built with students helped him know “where to draw the line on what is too much emotional investment.” Instructors described the positive aspect of working with the tutors and with each other as they developed the materials for the projects. Instructor A explained it this way:

> I learned something about improving how to ask questions. Because we worked on that—we hammered out not only questions but the wording of activities—I realized how important that is. When you are working by yourself, you don’t tend to ask yourself, “Does this really come across the way I want?” I learned that. I think I learned it was okay to not feel that I am in competition with other instructors. I think that can happen when you get together with other colleagues and feel like you have to compete with each other. I did not feel that at all.

Instructor E, however, noted that the collaboration could have been better, stating, “It was a challenge for the instructors involved to have the time to get together.” Another instructor talked about the collaboration between students, explaining that not all individuals in the groups would always work equally well together. He thought about, “how individual students were affected by working in groups—how some of them grew and how some of them reacted negatively” (Instructor B).

Extra help/special bond with tutor. On the first day of Instructor E's class, as he was telling the class about the required project sessions, he overheard a student tell another student, "The best part is that you get your own personal tutor." According to Instructor E, that student had heard about the supplemental session class from a friend who had taken the class in the fall. Students, in general, described a feeling that by taking this kind of class, they could always get extra help from their tutor. Student AZ stated, "Just having some extra time with the tutor each week went a long way in helping me with my math." One student, in describing the role the tutor played, explained, "It was nice to get a second person's input on what we learned in class and to answer questions" (Student EC). Student SC put it this way: "The tutor was just one of us. Whenever we talked about how old he was we told him you don't seem old; you seem like one of us." The tutors described a special connection with students in their sessions. Tutor H told how he heard from many of his students letting him know how they performed on the final exam. Instructor B stated that students told him they had "chosen not to withdraw because they had their own special tutor."

By far, the most poignant story came from Tutor I. He described the special bond formed with his class and one memorable evening.

> In the spring session, (I hope I can get through this—it's kind of emotional), in addition to meeting as a group, they also started to get together before midterms and things like that. For a couple of those sessions I showed up to help them out. One of them was when they were all coming here the night before the midterm; there was the night to do the review, the midterm the next day, and the drop deadline was the day after that. That review session happened to be on my birthday. But my family, we have always been we can celebrate our birthdays on the weekends and I told the students I would come. The

word got out that I was doing this on the evening of my birthday. And one student pulled me aside beforehand and said, "I was actually going to drop the class this afternoon but I knew that you were coming to the review session on your birthday. So here I am." And she passed the class. And she was also in the first trimester of her first pregnancy.

Involvement. Tutors made several comments about the involvement of some of the students in the class and the lack of attendance by others. One tutor noted that it was particularly difficult when only one student would show from a particular group. He would then have to put that one student in another group, which tended to disrupt their work (Tutor I). Tutor I described the challenges of getting students to attend this way: "One person deciding not to come to the group session that day affected others. It was a little different from missing a day of lecture for whatever reason. That had consequences beyond themselves." Instructors also lamented the difficulty they had getting students to attend the sessions, in spite of the fact that the sessions counted toward the students' final grades. Instructor D explained, "On any given day, if I had 15 students in the class, we were lucky to get 10 to attend the supplemental session." Instructor B described several students who hurt their grade because those students refused to participate in the sessions.

Summary

Quantitative analysis of data provided no evidence of significant improvement in persistence, successful course completion, or understanding of key course concepts for students in the experimental group. Further analysis suggested a lack of significant change in attitude toward mathematics among those same students. Results of the analysis of qualitative data, however, suggested a more robust relationship between the collaboration that occurred in the supplemental sessions, the strong relationships built with the tutor and other students, and persistence in the class. Further qualitative analysis of online postings and student interviews indicated an increase in students' ability to think critically and to communicate about mathematics.

Both the ARC initiative and the PSPI initiative provided evidence of some positive impact on success in mathematics. Before expanding either initiative, it is recommended that further research be conducted to determine which components led to increased student learning.

References

Achieving the Dream. (2010). *Case studies and results.* Retrieved from http://www.achievingthedream.org/ABOUTATD/CASESTUDIES/default.tp

American College Testing. (2006). *Ready to succeed: All students prepared for college and work.* Retrieved from http://www.act.org/research/policymakers/pdf/ready_to_succeed.pdf

Arendale, D. (2000). *History of supplemental instruction: Mainstreaming of developmental education*. Unpublished manuscript retrieved from https://cehd.umn.edu/CRDEUL/pdf/monograph/2-a.pdf#page=22

Blue Valley School District. (2011). District performance – awards and achievements. Retrieved from http://www.bluevalleyk12.org/education/components/scrapbook/default.php?sectiondetailid=1651

Boaler, J. (1998). Open and closed mathematics: Student experiences and understandings. *Journal for Research in Mathematics Education*, 29(1), 41-62.

Carnegie Foundation for the Advancement of Teaching. (2010). *What community college developmental math students understand about mathematics.* Retrieved from http://www.carnegiefoundation.org/problem-solving/developmental-math

Creswell, J. (2009). *Research design: Qualitative, quantitative, and mixed-methods approaches.* Los Angeles, CA: Sage publications.

Day, K., & Frost, J. (2009). Sharing the WARMth: Writing and reading mathematics in a learning community. *Learning Communities Journal, 1*(1), 91 – 111.

Gosser, D., Strozak, V., Cracolice, M., Kampmeier, J.A., Roth, V., & Varma-Nelson, P. (2001). *Peer-led team learning: A guidebook.* New York, NY: Prentice Hall

Johnson County Community College. (2010). *Credit course schedule.* Retrieved from http://metaweb.jccc.edu/student/ClassSearch/class/search/term_type/Credit

Johnson County Community College. (2011). *College Algebra course outline.* Retrieved from http://www.jccc.edu/home/course_outline.php/fall-2011/MATH171

MacGregor, J. (1994). Learning communities taking root. Retrieved from http://www.evergreen.edu/washcenter/natlc/pdf/spring1994.pdf

Manspeaker, R. (2010). *Attitude survey*. Kansas State University Department of Mathematics. Retrieved from http://www.math.ksu.edu/placement/attsurvey09.php

Olathe Public Schools. (2011). *Award highlights.* Retrieved from http://www.olatheschools.com/aboutus/awards/award-highlights

Tinto, V. (1998). Learning communities and the reconstruction of remedial education in higher education. From the Conference on Replacing Remediation in Higher Education at Stanford University. Retrieved from http://www.ntlf.com/html/lib/suppmat/74tinto.htm

Wagner, T. (2008). *The global achievement gap: Why even our best schools don't teach the new survival skills our children need – and what we can do about it*. New York, NY: Basic Books.

Weiss, N. (2010). *Introductory statistics, 8th edition.* New York, NY: Pearson.

Wilson, S. (2008). *Stability amidst perturbation*. Available upon request from swilson@jccc.edu

Appendix A: **Attitude Survey**

As part of our *Achieving the Dream* strategy to improve instruction, the math division at JCCC is collecting student data on attitudes toward learning mathematics. There are no right and wrong answers to this survey, but your answers may help us determine which type of math classes will help you learn best. Survey questions 3 – 10 were developed by the math department at Kansas State University; the Center for Quantitative Education at KSU has granted JCCC permission to use those questions.

Please place an **X** in the box of your choice.

	Strongly Agree	**Somewhat Agree**	**Ambivalent**	**Somewhat Disagree**	**Strongly Disagree**
1. I believe I can learn math concepts through group projects.					
2. Mathematics is a worthwhile subject to learn					
3. Being good at mathematics is something a person is born with, like being left-handed					
4. It is very important to me that I attend a small class where the instructor can keep track of my progress.					
5. If I don't know how to do a math problem, looking back at my class notes or the textbook is helpful.					
6. I usually only understand a new concept after working with a friend or a tutor.					
7. I anticipate using math in my future career.					
8. I am pretty confident in my math skills.					
9. If I miss class, I can learn the material on my own or with a tutor.					
10. Mathematics classes can be fun.					

Appendix B: **Interview Questions**

Phase one questions for students:

1. Could you describe your experiences in math classes prior to this class?
2. Could you describe your experiences in this math class?
3. Are there things that helped you learn? If so, what were they?
4. Are there things that made it difficult for you to learn? If so, what were they?
5. Has this class changed your attitude toward math in any way? If so, how?
6. Has this class changed your career plans in any way? If so, how?

Questions for tutors

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?
2. What did you learn by working with the instructor? Will you continue to use some of what you learned?
3. What did you learn by working with the students? Will you continue to use some of the things you learned?
4. What were some of the positive things you heard about the sessions from the students?
5. What were some of the negative things you heard about the sessions from the students?
6. Did you see examples of students who succeeded because of the sessions? If so, what were they?
7. Did you see examples where students were not successful because of the sessions? If so, what were they?
8. Is there anything else you want to share about your experiences with the sessions?

Questions for instructors

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?
2. What did you learn by working with the other instructors? Will you continue to use some of what you learned?
3. What did you learn by working with the tutor? Will you continue to use some of the things you learned?
4. What were some of the positive things you observed or heard about the sessions from the students?
5. What were some of the negative things you observed or heard about the sessions from the students?
6. Did you see examples of students who succeeded because of the sessions? If so, what were they?
7. Did you see examples of students who were not successful because of the sessions? If so, what were they?
8. Is there anything else you want to share about your experiences with the sessions?