Learning Communities Research and Practice

Volume 1 | Issue 1 Article 10

2013

Assessing the Effectiveness of a Learning Community Course Design to Improve the Math Performance of First-Year Students

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Abstract

National attention is focused on the persistent high failure rates for students enrolled in math courses, and the search for strategies to change these outcomes is on. This study used a mixed-method research design to assess the effectiveness of a learning community course designed to improve the math performance levels of first-year students. Results suggested that investing resources into learning community programs that help students meet collegiate-level math course demands helps promote academic success in math courses and eases students' college transitions. Participants in the math learning communities reported significantly higher rates of using academic supports, engaging in campus activities, and understanding general education learning outcomes compared to a quasi-control group of students enrolled in the same math courses. Math learning community participants enrolled in introductory algebra courses had higher levels of math performance compared to nonparticipants.

Cover Page Footnote

This article originally published in: Journal of Learning Communities Research, 5(1). (April 2010).

Assessing the Effectiveness of a Learning Community Course Designed to Improve the Math Performance of First-Year Students

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A mixed-method research design was employed to comprehensively assess the effectiveness of a learning community course designed to improve the math performance levels of first-year students. Results suggested that investing resources into learning community programs that help students meet collegiate-level math course demands may help promote academic success in math courses and ease students' college transitions. Participants in the math learning communities reported significantly higher rates of using academic supports such as math assistance centers (tutoring and mentoring), engaging in campus activities, and understanding general education learning outcomes compared to a quasi-control group of students enrolled in the same math courses. Math learning community participants enrolled in introductory algebra courses had higher levels of math performance compared to nonparticipants.

The purpose of this article was to investigate the effectiveness of a learning community (LC) course designed to improve the math performance and engagement levels of first-year college students. The transition from secondary math education to the university level is often an important factor to consider when examining the success rate of first-year students. Many high school students do not have the analytic and math skills necessary to solve the global challenges facing today's workforce or to be academically successful during the first year of college (Phelps, Camburn, & Durham, 2009). According to Bressoud (2009), president of the Mathematical Association of America, "There are serious problems in K–12 mathematics education, but college faculty also need to look to their own house and think about the first-year experience of their own students" (p. 1). He also asserts that there is a notable disparity between students' experiences in mathematics in high school and the expectations they encounter when they enter college. Math is taught differently at the college level than in high school, and it appears that many college students are unprepared to meet the demands of collegiate mathematics courses. In high school, students are typically provided the material they will need to pass the tests. They are not expected to read the textbook because instructors often give them all the necessary information in class. However, college students are expected to read the material prior to attending class and understand that the instructor may not be able to cover all the material from the assigned section(s) during class. As external pressures to graduate students in a timely manner have augmented over the past decade, designing effective first-year interventions to help ease transitions to college is now an almost unavoidable consideration for higher education faculty, administrators, assessment practitioners, and policy makers. Thus, it appears that designing effective interventions to improve the mathematics classroom environment may be an important step when trying to meet the academic needs of entering students.

University math instructors must be aware of the transitional problems first-year students may encounter. Students who have anxiety associated with math may tend to avoid math, perform poorly on math tests, and even exclude themselves from desirable career opportunities (Ashcraft, 2002). Ashcraft points out that it may be difficult to ascertain how math anxiety plays a role in low math competence in college-level math courses in particular because higher-level math courses, such as college algebra, tend to rely more heavily on working memory compared to high school math courses. Math anxiety tends to have a much higher impact on working memory compared to routine arithmetic processes (Ashcraft). According to Ashcraft, research on math anxiety has suggested that classroom methods that foster cognitive and motivational support may help to reduce math anxiety levels. Thus, creating supportive, collaborative classroom environments that help students overcome math anxiety may be an important consideration for math instructors.

Another area of concern is that most high school students adopt a surface-learning attitude (Kajander & Lovric, 2005). The learning communities approach may be effective for helping students engage in deeper levels of learning and helping them by providing opportunities to deal with complex issues as they figure things out for themselves, communicate and work with people from diverse backgrounds and views, and share what they learn with others (Bielaczyc & Collins, 1999). Deep learning involves thinking and the ability to adapt to new situations. According to Gabriel (2008), it is vital that students begin to accept responsibility for their learning progress. Gabriel advocates for fostering collaborative learning and ensuring that classroom time is set aside so that students can work with each other and instructors can help improve the learning process. Students need to develop their own supportive peer groups during the first year. Tinto (1998) found that students who participate in learning communities acquire important social as well as academic skills.

Learning communities (LCs) have been implemented on several campuses nationwide to help facilitate successful transitions and to improve the academic performance levels of students. In fact, there has been a resurgence in the implementations of LCs since the early 1980s principally due to the growing body of evidence that LCs are associated with a variety of desired outcomes (Henscheild, 2004). Learning communities have been advocated as effective interventions to enhance engagement levels (Yancy, Sutton-Haywood, Hermitte, Dawkins, Rainey, & Parker, 2008; Zhao & Kuh, 2004), student learning and academic success (Hegler, 2004; Henscheild; Kuh, 2008; Stassen, 2003; Tinto, 2003), critical thinking (Lardner & Malnarich, 2008), and integrative learning (Lardner & Malnarich, 2008, 2008/2009, 2009). Previous research has shown that participation increases student engagement and persistence (Oates & Leavitt, 2003). In a multiple institutional study, Zhao and Kuh found that participation in LCs was positively associated with a variety of educational outcomes such as academic performance, academic effort, academic integration, faculty-student interactions, engagement in diversity-related interactions, enrollment in classes that emphasize higher-order thinking skills, and satisfaction with college experiences. Stassen conducted an investigation into the effects of different levels of living-learning communities (e.g., mechanical linked courses in comparison to more faculty coordinated, resource extensive models) and found that even basic LC designs had positive impacts on academic performance, one-year retention, and academic integration (contact with peers around academic work, positive academic behaviors, and hours devoted to studying). Students in LCs have also been found to achieve higher levels of academic attainment compared to nonparticipating students (Hegler).

There are several activities and pedagogical strategies that have been found to improve students' levels of academic success and learning outcomes such as employing collaborative learning approaches (Chickering & Gamson, 1987; Gabriel, 2008; Wankat, 2002), helping students develop effective study skills (Porter & Swing, 2006), assisting with students' time management (Weinstein, 1988), enhancing students' understanding of their learning styles (Rachal, Daigle, & Rachal, 2007), and helping students navigate the university environment and understand campus resources available to help them (Bean & Eaton, 2001–2002). The most likely path for the vast majority of college students involves taking advantage of the myriad of academic support programs so they can attain their visions of academic success. Offering learning communities and first-year seminars has become a prevailing strategy among campus leaders and administrators for ensuring that students have enriching academic experiences. Numerous studies have demonstrated that first-year seminars help students adjust to college and attain positive educational outcomes (e.g., Dooris & Blood, 2001; Porter & Swing; Schnell & Doetkott, 2002–2003; Starke, Harth, & Sirianni, 2001). It seems that seminars and learning communities may be effective mechanisms for ensuring that math students have the opportunity to develop appropriate expectations; integrate their experiences; establish connections with faculty, staff, and students; engage in campus activities; and learn math actively.

Current Study and Research Questions

Taken together, past research suggests that first-year students may benefit from structured opportunities designed to help them with their study skills, time management techniques, learning styles, test-taking anxiety, and collaborative learning strategies. The math learning community interventions investigated in this study were designed with these transitional issues in mind. This study focused on assessing the effectiveness of math learning community courses that were offered to provide students with opportunities to engage in collaborative, hands-on, student-focused learning. Thus, the research was conducted to determine if math learning communities were effective mechanisms for improving first-year students' performance in math courses and engagement in learning. The intervention consisted of an undergraduate math-focused one-credit seminar course that was part of a curricular learning community. A math-focused seminar course was linked with an introductory or intermediate algebra course.

The math LCs were designed to offer an intentional first-semester experience for students and to help students see relationships among academic courses and campus activities. A mixed-method research design was employed to comprehensively assess the effectiveness of a learning community course designed to improve the math performance levels of first-year students. Grade performance information was extracted from institutional records. Students' perceptions of the course benefits were assessed by administering end-of-course questionnaires and by conducting in-depth face-to-face structured interviews. A mixed-method design was employed in an effort to enhance the ability to triangulate findings from qualitative and quantitative methods, to build conceptual frameworks, to "complement" by enriching and elaborating on the "phenomenon" of LC participation by employing different measures (Greene, Caracelli, & Graham, 1989), and to shed light on what learning community program aspects influenced positive outcomes by capturing in-depth students' perceptions (Reese & Miller, 2006). The following research questions guided our investigation: a) Do math learning communities help first-year students perform better academically?, b) Are math learning communities perceived as beneficial to students and do they enhance learning outcomes?, c) Do math learning communities help promote success in the following areas: perceptions of math self-efficacy, campus engagement, understanding and use of academic resources, the formation of study groups, time management skills, ability to manage and to cope with test math anxiety?, and d) What aspects of math learning communities are perceived as most beneficial to students?

Methods

Research Setting and Description of the Intervention

This study took place at a large, urban, public Midwestern university. The math learning communities were offered in the fall semester for first-year students and were created to assist with shaping the first-year student's college path. The LC courses consisted of a 1-credit first-year seminar course forming a curricular link with and enrolling the same cohort of students in either Introductory Algebra (Math 001) or Fundamentals of Algebra (Math 110), an intermediate algebra course. It is important to note that the seminar courses were all taught by the same instructor. Topics covered in the math-focused seminar course included learning styles, math anxiety, time management, study skills for math exams, and test-taking skills.

The math learning communities were taught by instructional teams consisting of faculty members, student peer mentors, advisors, and librarians. Activities and pedagogical strategies were used to introduce students to general education learning outcomes. Additionally, instructional strategies were employed to assist students in making career and major decisions. Faculty members were available to help in answering specific math questions as well as more general inquiries about math placement and planning. Other activities included math professor panels to enhance students' understanding of college-level expectations and to increase their levels of comfort with math faculty members. The importance of working problems and developing math problem-solving skills were also emphasized.

The LC courses provided a wide spectrum of information about campus services and academic supports. Another component of the math learning communities was getting the students involved with the campus. Students were required to attend campus activities throughout the semester to promote campus engagement levels. The purpose of this requirement was to help first-year students feel comfortable with the campus atmosphere. Students were also required to attend the Mathematics Assistance Center (MAC) throughout the semester. This campus facility was offered as a resource for math students needing extra help with their math classes. Mentors were available for math study sessions, and tutors were available for math questions. Students were encouraged to visit instructors during their office hours and get tutoring assistance through the MAC if they required additional help.

Participants and Procedures

Students' academic performance levels. A posttest nonequivalent group design was used to compare first-year math LC students' academic performance levels (cumulative first-semester grade point averages and grades in current and next semester math courses) with a quasi-control group of first-year students who were enrolled in the same math courses (introductory or intermediate algebra) but were not part of the math learning community. It is important to note that the quasi-control group was enrolled in the same math course but was not part of the cohort enrolled in the math seminar linked with the math course (forming the learning community). The math course enrollment was limited to a total of 50 students while the LC enrollment was limited to 25 students. By employing this method, we were able to control for differences between the LC group and comparison group with regard to math instructor, time of day, level of math course, and number of math course credits earned. Student grade data was extracted from institutional records rather than relying on students' self-reports of grade information.

There were a total of 58 first-year students who enrolled in and completed the three Introductory Algebra (Math 001) learning communities, and 59 were in the quasi-control group of students who enrolled and completed the three Introductory Algebra courses that did not form the LC. The average course load for the LC participants was 12.72, their average age was 19.39 (range 18–36), their average Math Scholastic Aptitude (SAT) test score was 425.11, and their average high school cumulative grade point average (GPA) was 2.84. Of this group, 74% were admitted to the university on a conditional basis, 67% reported that they were first-generation college students, and 69% were female. LC participants' race/ethnic characteristics were as follows: 74% were Caucasian, 24% were African American, and 2% were Asian American. The average course load for the quasi-control group students enrolled in the Introductory Algebra was 12.69, their average age was 19.69 (range 18–44), their average Math Scholastic Aptitude (SAT) test score was 438.11, and their average high school cumulative grade point average (GPA) was 2.89. Of this group, 61% were admitted to the university on a conditional basis, 64% reported that they were first-generation college students, and 66% were female. LC participants' race/ethnic characteristics were as follows: 77% were Caucasian, 19% were African American, 2% were Asian American, and 2% were Latino. The proportion of African American students enrolled in the math LCs was notably higher than the general university proportion of African American students (9%). The math SAT scores were notably lower for LC participants compared to nonparticipants.

There were a total of 21 first-year students who participated in the intermediate algebra (Math 110) learning community, and 12 students were in the quasi-control group of students who enrolled in and completed the intermediate algebra courses that did not form the LC. The other 10 students enrolled in the math course were not first-year students and were omitted from further analyses due to the fact that they were not an appropriate comparison group. The average course load for the LC participants was 13.19, their average age was 18.82 (range 18–20), their average Math Scholastic Aptitude (SAT) test score was 436.67, and their average high school cumulative grade point average (GPA) was 3.08. Of this group, 38% were admitted to the university on a conditional basis, 43% reported that they were first-generation college students, and 90% were female. LC participants' race/ethnic characteristics were as follows: 76% were Caucasian, and 24% were African American. The average course load for the quasi-control group students enrolled in the intermediate algebra was 14.33, their average age was 18.72 (range 18–20), their average Math Scholastic Aptitude (SAT) test score was 482.00, and their average high school cumulative grade point average (GPA) was 3.31. Of this group, 25% were admitted to the university on a conditional basis, 50% reported that they were first-generation college students, and 67% were female. LC participants' race/ethnic characteristics were as were as follows: 67% were Caucasian, 17% were African American, 8% were Asian American, and 8% were international students. The math SAT scores and high school GPAs were notably lower for the intermediate algebra LC participants compared to nonparticipants.

Student end-of-course questionnaires. A posttest nonequivalent group survey research design was used to compare first-year math LC students' perceptions of course benefits, learning outcomes, use of academic resources, math self-efficacy levels, campus engagement levels, and understanding of campus resources with a quasi-control group of first-year students who were enrolled in the same math courses (introductory or intermediate algebra), but were not part of the math LC. Students were asked to voluntarily respond to paper-based self-administered questionnaires during class time. Students were explicitly informed that their participation in the survey research project was completely voluntary and that results would be strictly confidential. There were no incentives offered for survey completion.

The survey sample consisted of 139 students (61 LC participants and 78 nonparticipants). The following were characteristics of the survey sample: 71% were females, 56% were conditional admits, 76% were Caucasian, 18% were African American, 2% were Asian American, 2% were Latino, and 2% were in the category of "other." The average age was 19.63. There were only 11 first-year students who did not respond to a survey. The only significant difference between the respondents and nonrespondents was in regard to SAT scores. The respondents' SAT scores were significantly lower compared to nonrespondents (889.22 and 935.60, respectively).

Student interviews. Semistructured interview protocols were designed to assess students' in-depth perceptions of learning outcomes and course benefits. Students enrolled in math learning community courses during their fall semesters were asked to voluntarily participate in face-to-face interviews. Students were explicitly informed that their participation in the interview was completely voluntary and that results would be strictly confidential. As an incentive, students were awarded a gift card valued up to $20.00.

Two undergraduate research assistants were trained in the fall semester to conduct effective interviews for the purpose of qualitative research. At the beginning of the spring semester, the trained undergraduates interviewed a sample of their peers who were enrolled in the math LCs. A random sample of 30 math LC students were contacted via e-mails from one of the two undergraduate interviewers, informed of the purpose of the study, and asked to participate on a voluntary basis. The students met the interviewers in a private room located in the Mathematics Assistance Center to complete the interview. The final sample consisted of 7 first-year math LC participants. Of the participants that were involved in the interviews, about 50% were female, 83% self-reported as being Caucasian, and 17% were African American. The average age of participants was 18.80 years old. All interviews were tape-recorded to ensure responses were accurately recorded.

Each interview session was transcribed, and the content was analyzed to identify the emergence of major themes.

Measures

Academic performance. We obtained measures of actual academic performance in math courses (grade on a 4.0 scale ranging from 0.0 to 4.0 in fall and spring semester math courses) and cumulative grade point averages earned during the first semester from university records (scale ranging from 0.0 to 4.0).

Students' perceptions of learning gains and course benefits: Student questionnaires. Students' perceptions of course benefits and learning outcomes were assessed by the following items developed specifically for the purposes of this study: "I am familiar with the [university's general education learning outcomes]," "I know my learning style," "I feel comfortable working in groups," and "I feel confident that I can do well in future math courses." Students responded to these items on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). These items were treated as individual items for the purposes of this study.

Math performance self-efficacy. Self-efficacy refers to students' evaluation of their competence to successfully execute academic tasks necessary to reach desired outcomes (Zajacova, Lynch, & Espenshade, 2005). According to Bandura (1997), a strong sense of efficacy enhances human accomplishment and personal well-being in many ways. Individuals with high confidence in their capabilities approach difficult tasks as challenges to be mastered rather than threats to be avoided. A high level of self-efficacy can enable individuals to persevere when faced with setbacks, frustrations, and inequities. We assessed levels of math-related academic self-efficacy by asking students to respond to eight items developed specifically for this study to ensure alignment with math LC goals and pedagogical strategies: "I feel confident that I can do well in future math courses," "I feel confident that I can manage and cope with test anxiety," "I feel comfortable reading a math book," "I feel comfortable studying for math exams," "I have a good understanding about my future required math courses," "There are lots of ways around any school-related problems that I may face," "I can think of many ways to reach my current academic goals," and "At this time, I think I can achieve the goals I have set for myself." Students responded to these items on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). The coefficient alpha reliability was .83.

Understanding of academic resources. Understanding of academic resources was assessed by two items: "I am familiar with the Mathematics Assistance Center (MAC) resources," and "I know about campus resources available to help me if I have academic difficulties." Students responded to these items on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). The coefficient alpha reliability was .55.

Use of campus resources and engagement. Use of the Mathematics Assistance Center (MAC) resources located on campus was assessed by asking students to respond to two items: "How many times did you attend mentoring/tutoring in the MAC this semester?," and "How many times do you think you will attend mentoring/tutoring in the MAC for your next math class?" Students were asked to respond to a scale that ranged from 0 to "more than 8 times."

The level of campus engagement was assessed by an item that read: "I attended campus activities this semester." Students responded to these items on a scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Study group formation. Forming study groups for the purposes of preparing for math course work was assessed by asking students to respond to two items: "How many times did you form a math study group this semester?," and "How many times do you think you will form a math study group for your next math class?" Students were asked to respond to a scale that ranged from 0 to "more than 8 times."

Time management skills. Students' perceived ability to manage their time effectively was assessed by three items: "I am able to 'budget' my time through time management activities," "I can maintain a balance between school and work demands," and "I understand the amount of time I need to devote to studying." Students responded to these items on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). The coefficient alpha reliability was .65

In-depth student's perceptions: Student interviews. The interviews were designed to enhance understanding of students' in-depth perceptions of the impacts of the math learning communities and what pedagogical strategies and activities were most effective. An exploratory content analysis was conducted to determine what major themes emerged. The following are samples of the questions asked: "What aspects of the learning community were most beneficial?," "Please describe how your math learning community helped you perform better on math exams," and "Please describe what you learned about math anxiety." Please see the Appendix to view a copy of the interview protocol.

Results

Effects of Math Learning Communities on Academic Performance

Analysis of covariance procedures were employed with academic preparation measures (high school cumulative grade point averages and Math Scholastic Aptitude Test Scores) entered as covariates to determine if

Introductory Algebra (Math 001) LC students had significantly higher math course grades and semester GPAs compared to the quasi-control group. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate. After adjusting for academic preparation, there was a marginally significant difference between the Math 001 course GPA for LC participants (2.22) and the course GPA for nonparticipants (1.86), $F(3, 82) = 3.69$, $p < .10$, partial eta squared = .05. The alpha level was relaxed to .10 due to concerns about the relatively small sample size and concerns about statistical power (Lipsey, 1990). Effect sizes were calculated based on Cohen's d defined as the difference between the means, M1 – M2, divided by standard deviation, s, of either group (Cohen, 1988). The effect size was .17 meaning that there was a small effect of the LC on math grade performance.

After adjusting for academic preparation, there was a significant difference between the LC Math 001 participants' cumulative semester overall GPA (2.50) and nonparticipants' cumulative semester overall GPA (2.04), $F(3, 87) = 5.07$, $p < .05$, partial eta squared = .06. There was a small effect of the LC on cumulative overall semester GPA as indicated by the effect size of .23. Table 1 displays the descriptive statistics for the Introductory Algebra (Math 001) LC participants and quasi-control group.

Table 1.
Introductory Algebra (Math 001) Descriptive Statistics for Learning Community Participants and the Quasi-Control Group

	Learning Community			Quasi-Control Group		
Variable	N	Mean	SD	N	Mean	SD
Math Course Grade	57	2.06	1.09	52	1.88	1.20
Cumulative Semester GPA	58	2.40	.93	58	2.07	1.13
Spring Math Course Grade	33	1.61	1.18	41	1.63	1.07
Math SAT Score	47	425.11	58.45	42	438.10	58.15
High School GPA	57	2.84	.33	54	2.89	.39

The small sample size associated with intermediate algebra (Math 110) LC participants and nonparticipants prevented the use of inferential statistical procedures. The LC Math 110 participants actually had lower math course GPAs and overall cumulative semester GPAs (1.64 and 2.11, respectively) during the fall semester compared to nonparticipants (2.07 and 2.48, respectively). However, the LC Math 110 participants had notably lower high school GPAs and Math SAT scores. The LC Math 110 participants had notably higher GPAs in their spring math courses compared to nonparticipants (1.78 and 1.69, respectively). Table 2 displays the descriptive statistics for the intermediate algebra (Math 110) LC participants and quasi-control group.

Table 2.
Intermediate Algebra (Math 110) Descriptive Statistics for Learning Community Participants and the Quasi-Control Group

	Learning Community			Quasi-Control Group		
Variable	N	Mean	S.D.	N	Mean	S.D.
Math Course Grade	17	1.64	1.40	12	2.07	1.35
Cumulative Semester GPA	21	2.11	1.14	12	2.48	1.14
Spring Math Course Grade	12	1.78	1.56	11	1.69	1.37
Math SAT Score	15	436.67	50.80	10	482.00	54.32
High School GPA	21	3.07	.40	11	3.31	.33

Students' Perceptions of Learning Gains and Course Benefits: Student Questionnaires

Independent samples t-tests were conducted to determine if the math LC participants had significantly higher perceptions of course benefits and learning outcomes compared to nonparticipants. Results suggested that the only significant difference was in the area of understanding the university's general education learning outcomes. The math LC participants reported significantly higher levels of understanding ($M = 3.54$, $SD = .94$) compared to nonparticipants ($M = 3.07$, $SD = 1.31$), $t(1, 134) = 2.45$, $p < .05$). The effect size was .22 meaning that there was a small effect of the math LC on students' levels of general education learning outcomes.

Math Performance Self-Efficacy

An independent samples t-test was conducted to determine if the math LC participants had significantly higher perceptions of math self-efficacy levels compared to nonparticipants. Results suggested that there was not a significant difference between the math LC participants' math self-efficacy perceptions ($M = 3.86$, $SD = .53$) compared to nonparticipants ($M = 3.91$, $SD = .64$), $t(1, 127) = -.51$, $p = .61$).

Understanding of Academic Resources

An independent samples t-test was conducted to determine if the math LC participants had significantly higher levels of understanding campus resources available to help them with math-related academic difficulties compared to nonparticipants. Results suggested the math LC participants reported significantly higher levels of understanding ($M = 4.09$, $SD = .57$) compared to nonparticipants ($M = 3.67$, $SD = .87$), $t(1, 132) = 3.31$, $p < .01$). The calculated effect size was .28 meaning that there was a small-to-moderate effect of the math LC on students' levels of math resources understanding.

Use of Campus Resources and Engagement

Independent samples t-tests were conducted to determine if the math LC participants reported significantly higher levels of campus resources usage (actual behaviors) and planned to use the campus resources in the future compared to nonparticipants. Results suggested that the math LC participants tended to actually use campus resources such as the MAC more ($M = 3.31$, $SD = 1.44$) than nonparticipants ($M = 1.54$, $SD = 1.05$), $t(1, 137) = 8.06$, $p < .001$). Approximately 65% of LC participants reported that they used the mentoring/tutoring services offered by the MAC 3 or more times in the semester, while only 12% of nonparticipants used the MAC services 3 or more times during the semester. The effect size based on Cohen's d was .57 meaning that there was a moderate-to-large effect of the math LC on students' levels of usage.

Results also suggested that the math LC participants planned to actually use campus resources such as the MAC in future semesters more ($M = 3.77$, $SD = 1.67$) than nonparticipants ($M = 2.72$, $SD = 1.70$), $t(1, 134) = 3.59$, $p < .001$). Approximately 93% of math LC participants reported that they plan to use the mentoring/tutoring services offered by the MAC 3 or more times in future, while only 68% of nonparticipants plan to use the MAC services 3 or more times during future semesters. The effect size based on Cohen's d was .30 meaning that there was a small-to-moderate effect of the math LC on students' planned levels of usage.

Results suggested that the math LC participants tended to actually engage in campus activities ($M = 3.95$, $SD = .97$) more than nonparticipants ($M = 3.18$, $SD = 1.25$), $t(1, 136) = 4.06$, $p < .001$). The effect size based on Cohen's d was .33 meaning that there was a moderate effect of the math LC on students' levels of campus engagement.

Study Group Formation

Independent samples t-test were conducted to determine if the math LC participants were significantly more likely to actually form study groups or plan to form study groups in future semesters compared to nonparticipants. Results suggested that there was not a significant difference between the math LC participants' study group formation tendencies ($M = 1.80$, $SD = 1.06$) compared to nonparticipants ($M = 1.85$, $SD = 1.49$), $t(1, 137) = -.19$, $p = .84$). Results also suggested that there was not a significant difference between the math LC participants' future plans to form study groups ($M = 2.56$, $SD = 1.26$) compared to nonparticipants ($M = 2.43$, $SD = 1.37$), $t(1, 136) = .57$, $p = .57$).

Time Management Skills

An independent samples t-test was conducted to determine if the math LC participants had significantly higher perceptions of their ability to manage their time effectively compared to nonparticipants. Results also suggested that there was not a significant difference between the math LC participants' perceptions of time management abilities ($M = 4.00$, $SD = .61$) compared to nonparticipants ($M = 3.96$, $SD = .64$), $t(1, 131) = .37$, $p = .71$).

Student Interviews

The majority of students reported that activities dealing with math problem solving and the actual practice of math were the most useful aspects of the math learning community class. For example, one student reported, "We do math [problem-solving] work in class and it's like you have two classes right in a row where you learn to study the same thing." Another student indicated that the math LC helped him learn that it is important to "take an hour or two just do practice problems," while another student indicated that the math LC helped him to "focus more on math practice." In the words of another student, through the math LC experience and working with other students: "I found out that it is not only me that struggles with math. People I had come over every week. ... everyone would do the problem and we see what answers we come up with then just check every problem." When queried about how the math LC helped them most, many students also reported that the course improved their study habits.

One student remarked that he modified his study skills by employing the following technique: "[I] will go through the book and read a technical version on how to do something myself instead of listening to the professor." Another student reported that she learned to prepare for exams by "writing down the problems and doing it myself, then going back and checking the answers." Another student reported that she improved her study technique in the following manner: "When I'm studying or preparing I like to talk my way through the problem so that way when I'm taking the test I'll kind of whisper and it will come back to me."

Although the end-of-course survey results indicated that there was not a significant difference between the math LC participants' perceptions of time management abilities compared to students not participating in the math LCs, the in-depth face-to-face interview results suggested that the math LC seemed to be effective in influencing students to be more organized with course work generally and more diligent about practicing math routinely. Students were able to cite specific examples of how their first-semester math LC helped to shape their time management skills and habits. Many responses suggested that the course had notable impacts. Some of the students said that the pedagogical strategies employed in the math LC course enhanced their understanding of the importance of time management techniques. For example, some students reported the following insights: "Time should be set aside for doing math problems.... so you don't have to cram for a test and still end up getting a bad grade," and it is important "not to cram myself full of math the night before a test." Other students reported that they learned simple, but useful time management techniques such as how "to use a calendar," "stuff should be on a schedule and should be done at certain times instead of everything just done whenever," and "to plan, not procrastinate."

Results suggest that the math LC faculty members used effective techniques to introduce students to the concept of coping with and managing anxiety specifically related to mathematics problem solving and test taking. The sessions designed to help students cope with math anxiety seemed to be particularly useful, especially for students entering the college with concerns about anxiety serving as a potential impediment to their mathematics achievement. Students noted a wide array of math-anxiety-related issues that the math LC course helped them deal with such as maladaptive worrying, difficulties with relaxing, and test-taking anxiety. Students reported that the LC helped them in the following areas: "helped [me] to relax... and think about what I was doing so it helped me learn more than just hurrying up to get done and just to not worry about it," "I learned that most problems that people have when it comes to taking a test is that they don't know how to just relax and take their time and concentrate," and "I learned to take my time, to work through a problem slowly, and that if I didn't get one at that time to finish the test and come back to it." One student enthusiastically remarked that the LC "gave us different skills that we can use to help us relax before a test," while another reported that he learned "that if you're getting pressure before a math test ... do something to get your mind off it."

The interviews were also designed to incorporate students' voices when making decisions about math LC course improvements and curriculum development. When asked to describe how they would improve the math LC, many students reported that more time should be devoted to completing math problems and discussing difficulties associated with students' math courses. Students made the following recommendations: "More math [problem-solving activities] in class it would have been helpful... possibly devote 15 minutes of class to do a problem or two that were exceptionally hard," "Could spend more time doing practice problems," "Math should have been gone over everyday... practice problems," "Do more math practice," and spend "More time working with practice problems and going over tests problems."

Limitations

Although there are several strengths associated with mixed-method designs such as an enhanced ability to triangulate or "converge" findings from qualitative and quantitative methods, to build conceptual frameworks, to "complement" by enriching and elaborating understanding of the phenomenon by employing different measures (Greene, Caracelli, & Graham, 1989), and to understand what program components are associated with positive outcomes by capturing students' perceptions (Reese & Miller, 2006), this study also has several limitations. One of the most serious limitations of this study is the relatively small sample of students that participated in the interviews. We used quantitative surveys and institutional data on educational achievement (e.g., grades in math courses and overall semester GPAs) to provide a detailed picture of the math LC experience, causes of student math performance, and consequences of the math LC participation. Additionally, we employed student interviews to collect in-depth experiences of students' participating in math learning communities. Our intent was to obtain qualitative information about the math learning communities so that we could enrich our understanding of how the intervention improved students' transitions to college and math performance levels. However, the small sample of students participating in the interviews somewhat limited our ability to triangulate or complement the quantitative findings. The interviews did shed light on what intervention components were most helpful: math problem-solving activities, time management lessons, and sessions to help cope and manage math-test anxiety.

Another noteworthy limitation is that students self-selected into the math learning communities, and selection bias may have affected the internal validity of this study. It is possible that the positive effects of participating in the math LCs were due to the fact that students who enrolled in the math courses differed in substantial ways from nonparticipants, and these differences (not the intervention) caused the positive outcomes. Although it is possible that the most motivated and prepared students participated in the intervention, the math LC students tended to have slightly lower levels of past academic performance (high school cumulative grade point averages) and notably lower math domain SAT scores compared to nonparticipants.

This study details a comprehensive single-institution investigation of math learning communities and efforts to help first-year students make more successful transitions to college and perform better in their math courses. Arriving at effective math learning community interventions and pedagogical strategies is a complex process, and this study may be limited to a specific time, course, and group of students. With this in mind, the results may not generalize to other institutions, courses, or students. Additionally, this study focused on students enrolled in lower-level math courses (introductory and intermediate algebra courses) and did not address the needs of students who place in higher-level math courses. Thus, the results of this study may not generalize to math LC courses offered to students who place and enroll in upper-level math courses. This study may also only generalize to large, public, urban, commuter campuses and not to small residential or private liberal arts institutions. Future investigations employing large samples at a variety of institutions are needed to enhance understanding of how students perceive various strategies and what strategies are most effective in terms of producing desired educational outcomes (e.g., engagement, academic performance, sense of belongingness, and learning gains).

Discussion and Implications

A mixed-method research design was employed to comprehensively assess the effectiveness of a learning community course designed to improve the math performance levels of first-year students. The math LC course curriculum was designed to assist with first-year students' transitions to college and improve their academic performance levels in current, as well as future, math courses. Results suggested that investing resources into LC programs that help students meet collegiate-level course demands may enhance their academic success in math courses as well as their overall academic achievement. Math LC participants in lower-level math courses (Math 001 or Introductory Algebra) had significantly higher levels of math performance and overall semester cumulative GPAs compared to nonparticipants, even while taking into account levels of academic preparation. Thus, LC students seemed to learn transitional skills that generalized to enhancing their overall academic success rates. Although students in the intermediate algebra LC did not perform significantly better in their fall semester courses overall or in their math course, they did have notably higher grades in their spring math courses compared to the quasi-control group despite notably lower levels of academic preparation.

Contrary to expectations, LC math students did not report higher levels of math performance self-efficacy beliefs. In other words, they did not feel more confidence in regard to performing well in future math-related tasks such reading a math book, doing well on future math tests, and studying for math exams compared to students in the quasi-control group. Students not enrolled in the math LCs had slightly higher high school GPAs and notably higher SAT math domain scores compared to the math LC participants. A higher proportion of the math LC students were also admitted to the university on a conditional basis compared to the quasi-control group students. It is possible that their prior academic success helped to bolster their feelings of efficacy in terms of their future math grade performance. Math LC students also did not report significantly higher tendencies to form study groups compared to the quasi-control group. Although the results were not statistically significant, it may be practically significant that the majority of the math LC participants (54%) reported that they formed a study group, while only about one third of the quasi-control group (37%) formed a study group. Results from the in-depth interviews indicated that students were benefiting from study group processes as one student reported: "There were five of us and we met once a week… I learned they [study groups] help a lot!"

Although questionnaire results suggested that the math LC participants did not report significantly higher perceptions in terms of their ability to manage their time effectively compared to nonparticipants, in-depth interview results revealed that the LC participants found that the time management sessions were particularly beneficial and assisted them when making the transition from high school to college.

Participants in the math LCs reported significantly higher rates of using academic supports such as math assistance centers (tutoring and mentoring), campus engagement, and understanding of general education learning outcomes compared to a quasi-control group of students enrolled in the same math courses, but not participating in the math LCs. Structured interview results suggested that students found the LCs particularly valuable in the following areas: helping them develop math problem-solving skills, providing a forum for discussing difficulties associated with their math courses, improving their time management skills, and helping them cope and manage math-test anxiety. Ideally, results of comprehensive assessment projects are used to improve teaching and learning processes. It is notable that the math LC faculty members involved in this study have used the results of this investigation to make fundamental pedagogical and curriculum changes such as incorporating more mathematics problem solving, using more collaborative learning strategies in which students solve math problems in small groups, and developing more sessions devoted to time management and math anxiety. The University College Curriculum Committee also used the results to make a critical curriculum decision: a 2 credit math-focused seminar will be offered in future semesters. The curriculum change was proposed to allow students more time for math problem solving, building study skills, and collaborative group work.

The combination of quantitative and qualitative research findings seemed to indicate that students react positively to early interventions that facilitate campus connections, help them understand campus resources, explain the purposes of general education learning outcomes, and equip them with skills necessary to adjust effectively to college. The collaborative learning atmosphere associated with participating in a math-focused seminar linked with a math course seemed to have a greater impact than stand-alone courses. It appears that students enrolled in the math LC had varying needs in terms of understanding their time management skills, math anxiety levels, and learning styles. Math LC programs that are tailored to meet the diverse needs of students may be optimal. Ideally, this research is used to develop curriculum and to gain support for innovative pedagogical strategies to assist first-year students enrolled in math courses on other college campuses. Results suggest that developing math learning communities that focus on math problem-solving skills, help students cope with math anxiety, enhance students' time management skills, facilitate the use of campus resources and involvement in campus activities, and devote attention to developing supportive, collaborative learning atmospheres may help students perform better in their math courses.

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Appendix

Math Learning Community Student Interview Protocol

Thank you for coming today/this evening. I appreciate that you have taken time out of your busy schedule to participate in this survey interview. My name is _____________. My role is to conduct interviews with students enrolled in math learning community courses. You were randomly selected from a list of students enrolled in math LCs to provide important information about your experiences.

This interview has been designed to gather information about your opinions, experiences, and expectations concerning math LC courses.

This interview will last approximately 1 hour. Your participation is voluntary and the results will be strictly confidential. Please understand that you may leave the interview at any time. The results will not be used to make decisions about individual students. Results will be reported in summary form with no names or identities included and will be used to make course improvements.

The interview will be tape-recorded to make sure that your opinions are accurately recorded. Again, your name will not be linked to your responses. Upon completion of this interview, you will receive a $20 gift card.

Do you have any questions before we begin? Clarify that all questions relate to their experiences in the math learning community courses.

Questions:

1. What aspects of your math learning community were most beneficial?
2. Please describe how your math learning community helped you perform better on math exams.
3. Please describe what was least helpful about your math learning community.
4. Please describe how you would improve the math learning community.
5. What did you learn from the test taking/study skills sessions?
    a. How did you apply what you learned?
6. What did you learn about math anxiety?
    a. How did you apply what you learned?
7. What did you learn from the professor panel?
    a. How did you apply what you learned?

8. What did you learn from the time management sessions?
   a. How did you apply what you learned?
9. What did you discover about the way you learn?
   a. How did you apply what you learned about yourself in studying/ preparing for math exams?
10. Did you form any study groups this semester? (Probes: Tell me more about the study group? How often did you meet?)
    a. How did you apply what you learned from the study group experience?
11. What types of study skills did you learn?
    a. How did you apply the study skills when preparing for math exams?
12. Is there anything that was not covered in your math LC course this semester that would have helped you do better on your math exams?
13. Do you have any other comments?

13. Ask and document the following: Gender ____________ Age _____ Race/Ethnicity _________________

Thank all students for their time and give them further information about the study.