Supplemental instruction in developmental mathematics

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Mirroring the changing demographics of the nation, the community college student population continues to grow in size and diversity. Almost half of all students who enter these institutions need at least one remedial course—which is often developmental mathematics. Developed in 1973, Supplemental Instruction (SI) has quickly gained recognition as an academic support program used to aid student performance, retention, and academic success. Still in its infancy, SI positively influences student achievement. Preliminary findings from descriptive research at Valencia Community College, Orlando, Florida, encourage these researchers to further examine the utility of SI in creating a climate of achievement for learners in developmental mathematics courses.

Introduction

Community colleges continue to play an indispensable role in providing underrepresented populations access to higher education. Pioneers in "the paradigm shift from a focus on teaching to improvement of student learning" (Arendale, 1998) and in implementation of the learning college (O'Banion, 1997), these institutions face the daunting task of offering instruction in developmental courses to a growing number of students. Concurrently, in an age of accountability, community colleges are mindful of the ever present need to maintain academic standards and improve student retention. While perplexed by burgeoning enrollments, increasing student diversity, and limited resources, community colleges are simultaneously challenged to provide greater evidence of student achievement (Warren, 2003).

Since the formalized inception of American higher education at Harvard in 1636, postsecondary education has changed from serving an elite homogenous group of students (restricted by class, gender and race) to serving a more heterogeneous group (characterized by variation in student academic readiness) (Hodges, 2001). In the wake of these noticeable shifts in student demographics, community colleges have given considerable attention to multiculturalism and diversity as they correlate to retention and academic success for all students (Levin, 2000). Almost half of all students who enter these institutions need at least one remedial course (Schuetz, 2002), which is often mathematics. National data indicates that large numbers of students enrolling in two- or four-year institutions are underprepared in mathematics. Thus, having completed K-12 education, high school graduates and returning students are enrolling in Pre-Algebra, Beginning Algebra, and Intermediate Algebra, all of which are regarded as precollege level and/or college preparatory mathematics.

Historically, the community college has provided open access to diverse populations at relatively low cost (Harbour, Middleton, Lewis & Anderson, 2003). While "students 'at-risk' were at one time considered a special group needing specialized help, current definitions of the student 'at-risk,' however, describe the majority of students in American community colleges" (Perez, 1998, p. 63). In this setting, a fundamental part of the institution's founding mission is to explore retention strategies that *sort*, *support*, *connect*, and *transform* students (Perez, 1998). Thus, "at-risk" students will have greater probability of successfully matriculating on community college campuses without dilution in academic standards (Burmeister, 1996).

Over the years, numerous programs have been used to assist students having academic difficulties (Boylan, 1999; Simpson, Hynd, Nist & Burrell, 1997). Jarvi (1998) contended that academic support and assistance programs, while common on college and university campuses, have not always been warmly received. These programs, which are designed to increase the success rates of students, have included orientation seminars, tutorial sessions, discipline-specific help, learning assistance centers (LAC), learning labs, and/or individualized learning programs.

Adding to the list is a recent educational innovation, which originated in the early seventies—Supplemental Instruction (SI). Hodges (2001) remarked that "two of the more common forms of academic assistance available to students are tutoring and SI" (p. 2). Peer learning—"a generic term which refers to situations where students support each other in educational settings" (Ashwin, 2003, p. 159)—is becoming an increasingly useful and viable retention strategy. SI, a form of peer learning which targets high-risk courses, is a nationally recognized academic support pro-

gram that has been used effectively to aid student performance, retention, and academic success (Martin & Arendale, 1993).

Supplemental Instruction (SI): an overview

Introduced by Deanna Martin in 1973 at the University of Missouri-Kansas City, SI has been implemented at a variety of institutions, both domestically and internationally. David R. Arendale (2003), who has published extensively on the topic, provides an overview:

> The Supplemental Instruction (SI) model of academic assistance helps students in historically difficult classes master content while they develop and integrate learning and study strategies. Goals of SI include: (1) improve student grades in targeted courses; (2) reduce the attrition rate within those courses; and (3) increase the eventual graduation rates of students. All students in a targeted course are urged to attend SI sessions, and students with varying ability levels participate. There is no stigma attached to SI since historically difficult courses rather than high risk students are targeted. SI can be implemented in one or more courses each semester.

As founder of SI, Deanna Martin targeted "high-risk courses" rather than high-risk students. A "high-risk course" is operationally defined as any college credit course in which at least 30 percent of the students receive poor marks of "D," "F," or "W" (withdrawal) (Burmeister, 1996). It is perceived by students to be conceptually difficult (McCarthy & Smuts, 1997), based on GPA earned in the course and success rate upon course completion (Martin & Arendale, 1993). Martin's intent was to assist medical students, particularly minorities, in courses that were perceived as difficult, thereby improving overall college retention.

Maxwell (as cited in Wright, Wright & Lamb, 2002) describes SI as follows: (a) a form of group tutoring; (b) designed to assist students with their reading, critical thinking, and study skills; and (c) led by peer undergraduates. Many studies (Martin & Arendale, 1993; Congos & Schoeps, 1993; Ramirez, 1997; Martin, Blanc, & Arendale, 1996) have recommended that institutions adopting SI use it only in non-remedial settings with high-risk, demanding courses. SI is proactive—rather than reactive—assistance to individual students. Problems with conceptual difficulty are addressed, presumably before they occur, because SI is open to all students enrolled in a specific "at-risk" course.

"In SI, the peer learning sessions take place *outside* the mainstream curriculum with the SI users' attendance at the sessions being voluntary" (Ashwin, 2003, p. 160), although some experimental research (Hodges, 1997) advocates mandatory attendance. Sessions

focus on helping students master success skills such as note-taking, test-anxiety issues, and time-management (Maxwell, 1998). McCarthy and Smuts (1997) found that the learning community developed in SI improved student performance, retention, and graduation rates. Research findings indicate that students who participate in SI have significantly better GPAs than those who do not participate in the sessions. Moreover, participants tend to re-enroll at a higher rate and maintain full- or part-time status for two semesters. In empirical studies, SI has proven to have a positive effect on special populations, such as developmental and minority students.

Key personnel in SI

Arendale (2003) identifies four key persons associated with SI: the *supervisor*, a trained professional; the *faculty member*, the teacher of the course; *the leader*, either a student or learning center staff member; and the *participating students*. Typically, sessions are conducted by leaders, students who have already taken and passed the "high-risk course" with at least a "high B" average. These students, who are integral to the SI program, are paid to attend all sessions of the referent course, take notes, read all assigned material, conduct weekly pre-scheduled SI sessions, and receive training in specific teaching/learning theories and techniques.

For example, in a typical session, the leader might conduct one or more of the following activities: instigate a discussion of class notes and clarify any misconceptions, present a mock test or quiz, or create a cooperative activity for students to complete. Leaders are students who know *how* to be students. Leaders are considered model students, given their understanding and knowledge of content and subject matter. The leader is a peer, embodying the skills necessary for responsible life-long learning (Martin, Blanc & Arendale, 1996) and providing a role model for successful college adjustment.

SI programs

In 2000, Arendale reported at least 735 SI programs in institutions of higher education within the United States. Community colleges with strong SI programs are Leeward Community College (LCC) in Hawaii (http://emedia.leeward.hawaii.edu/si/si_program.htm) and Oakland Community College (OCC) in Michigan (http://www.oaklandcc.edu/iic/iicor/or_sg.htm). LCC has had a program since Spring 2002 and is recognized for its approach to training the SI leader. In 2004, its session on training SI leaders was extremely well attended at the Third International Conference on SI. Kayla Phillips shared innovative ways to helps transform model students into model SI leaders. OCC is recognized for using SI in all developmental courses, not only mathematics, but also writing and English. While OCC refers to its program as Study Group Learning, the basic premise of SI is maintained.

Universities with notable SI programs include Texas A&M University (TAMU) and the University of Missouri, Kansas City (UMKC). TAMU has an award-winning Supplemental Instruction program (http://www.tamu.edu/cae/si/shtml) that is recognized for its reshaping of the typical 50-minute session. Leaders plan sessions that consist of three parts—a 10-minute warm-up activity; a 30-minute group interaction activity; and a 10-minute closing activity. UMKC, where Deana Martin conceived the idea of SI, (http:///www.umkc.edu/cad/SI/), is an ideal referent source for those institutions that are beginning to explore its use.

Several international institutions use SI. For example, Lund University (Sweden) is the sponsoring institution for the Fifth International Conference on Supplemental Instruction in June, 2006. Leif Bryngfors, an early adopter of SI at Lund, is an award-winning researcher/organizer of SI conferences internationally. He was recognized as such at the Third International Conference on Supplemental Instruction in Boston, 2004. Details of Lund University's Supplemental Instruction program can be reviewed at the following Web site: (http://www.si-mentor.lth.se/SI_eng/index_eng.htm).

Factors affecting student attrition

Tinto's landmark research on student persistence, which identifies factors that relate to student attrition, is probably one of the most frequently cited retention models in the professional literature (Blanc, DeBuhr, & Martin, 1983; Boylan, 1999; Commander & Stratton, 1996; Martin & Arendale, 1993; Martin, Blanc, & Arendale, 1996; Ramirez, 1997). In his research, Tinto discovered that incoming students were unable to meet the minimum standards required in their entry-level courses.

Tinto identified four factors—adjustment, isolation, difficulty, and incongruity—that contribute to student attrition during the first year of college. Learners in the community college setting are no strangers to these issues. *Adjustment* to college appears to be problematic for almost all students (Martin, Blanc, & Arendale, 1996), while *isolation* is perhaps exacerbated by the increasing diversity in the student population. The diversity may lead to *difficulty* in academic and social relationships thus creating *incongruity*, the inability of students to interact successfully both socially and intellectually in campus life.

Adjustment

Many underprepared college students do not know how to study (Martin & Arendale, 1993) because they have not yet developed the abstract reasoning skills that allow them to learn new ideas simply by reading a text or listening to a lecture. Working in situations with learners who are more capable improves content compre-

hension. Moreover, proponents of SI claim that it does more than just review content material. SI reportedly helps students engage in thinking behavior which facilitates connections between notes, textbooks, and problem-solving (Martin & Arendale, 1993). SI sessions integrate study skills into the specific "high-risk courses," which helps learners figure out the best methods of assimilating the material (Wolfe, 1998).

Isolation

SI combats social isolation by helping students make connections to other students and session leaders. All students in the session share a common focus and goal (Martin, Blanc, & Arendale, 1996). Several studies have demonstrated the effectiveness of peer group learning (Tinto, 1993). The studies on cooperative learning groups also support the findings of developmental psychologists such as Piaget, Bruner, and Vygotsky (Driscoll, 2000). The session provides a non-threatening environment where students, despite culturally diverse backgrounds, can meet and get to know one another through learner-learner and learner-content interactions (Martin & Arendale, 1993).

Difficulty

By definition, students enrolled in developmental coursework are likely to experience and/or have experienced academic difficulty. SI was developed for "high-risk courses" and those that are perceived to be difficult by both the student and the teacher (Martin, Blanc, & Arendale, 1996). Typically, it is attached only to courses in which 30 percent or more of the students get a "D," "F," or "W." Research indicates that implementation of SI may be hampered unless both students and teachers perceive the course to be difficult (Blanc, DeBuhr & Martin, 1983; Hodges, 2001; Martin & Arendale, 1993; Martin, Blanc & Arendale, 1996). Moreover, students engaged in developmental coursework, particularly in the community college setting, experience difficulty integrating into the mainstream college-level mathematics curriculum. SI provides an ideal conduit for minimizing difficulty in academic and social integration for these learners. Arendale (2002) has offered SI as a vehicle for delivering the best practices of developmental education into the mainstream of higher education teaching and learning.

Incongruence

A primary focus of SI sessions is aiding student assimilation and understanding of course content by thinking, reasoning, analyzing, organizing, and problem-solving. Students practice skills to gain concrete experience with application of ideas while using the language of the subject matter (Hodges, 2001). SI sessions—by helping students achieve academic success—enable them to feel a part of the intellectual college community (Martin, Blanc, & Arendale, 1996). Not

only does SI encourage academic success, but also it encourages students to work together as a team towards a common goal.

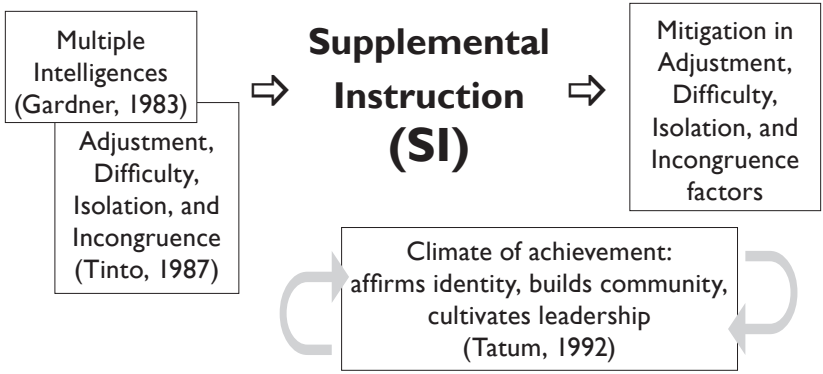
A conceptual framework for Supplemental Instruction

SI has the capacity to provide solutions that circumvent many of the obstacles identified in Tinto's research. A conceptual framework (See Figure 1) for supplemental instruction can be derived from literature on the multiple intelligences theory (Gardner, 1983); from the student retention and attrition theory (Tinto, 1993); and from Beverly Daniel Tatum's (1992) ABC student achievement theory. Tatum asserts that affirming identity, building community, and cultivating leadership are important factors when creating a climate of achievement for minorities. Regardless of race and/or ethnicity, however, these concepts seem equally important for ensuring success of all students.

Tatum's theory complements that of Goleman (1995), who asserts that individuals have two primary emotional intelligences—interpersonal and intrapersonal—that substantiate a need for interaction and reflection among learners. Overall, the conceptual framework posits that learners in the community college setting arrive with strengths and weaknesses in multiple intelligences; experience adjustment, isolation, difficulty, and incongruence; and may potentially experience a climate of achievement through participation in SI sessions.

In recognizing multiple intelligences (Gardner, 1983) and traditional factors that affect student assimilation, attrition, matriculation, and retention, SI sessions offer an intervention strategy that may give previously unsuccessful students a second chance at integration into the college community (Martin & Arendale, 1993). SI leaders aid the process through creating a climate of achievement (See Figure 1).

Figure 1. SI as a process for creating a climate of achievement for diverse learners through academic and social integration in an interdependent learning community.



The learning-centered community college

Brookfield (2002) has suggested that faculty view their teaching practice through four complementary lenses—their autobiographical experiences as learners, students' eyes, colleagues' perceptions, and educational literature—to develop a critically reflective stance toward the practice of community college teaching. Levinson (2003) agrees, challenging faculty members to take a constructivist view of their daily work, thereby becoming critically reflective practitioners whose efforts have a demonstrable practical bent in classroom settings.

A learning-centered college is staffed by individuals—faculty, support staff, and administrators—who actively want to find answers to the following questions:

- What are the core skills, competencies, and content knowledge that we want our students to learn?
- How can we ensure that our students are learning?
- What evidence do we have—in the form of product deliverables—that authentic learning is taking place?
- How can we—as members of a learning-centered institution—contribute, individually and collectively, to teaching for optimal student learning?

The focus in today's community college is not teaching, nor learning, nor even teaching and learning. Rather, the current priority, particularly at learning-centered institutions is teaching for optimal learning (Evans, 2005). In summary, then, a learning-centered institution espouses and supports lifelong learning for all: students, faculty, administration, and staff.

Valencia Community College: A learning-centered response

Valencia Community College in Orlando, is a comprehensive institution, which serves Orange and Osceola counties in Central Florida. Founded in 1967, Valencia has six campus locations. It is the largest community college in central Florida, serving more than 43,000 students annually. The student population is diverse, with almost half being minorities. Sixty-four percent of Valencia students are part-time. Approximately 80 percent of the students are enrolled in one of 50 areas of concentration for Associate in Arts degree programs and plan to continue education at a university. At Valencia, core competencies for graduates are *think*, *value*, *communicate*, and *act*. These competencies guide faculty in the development of student learning goals. Based on entry-level placement scores, approximately 66 percent of students test at a low competency level in mathematics. Accordingly, these students are considered underprepared or "at-risk." Invariably, the students begin their mathematics curriculum in developmental courses, spe-

cifically MAT0012: Pre-Algebra or MAT0024: Beginning Algebra. Each course has a low success rate college-wide—50 percent and 46 percent respectively. Yet, another pre-college level mathematics course (not technically considered developmental mathematics) is MAT1033: Intermediate Algebra. Recent data on MAT1033 reports only a 51 percent success rate.

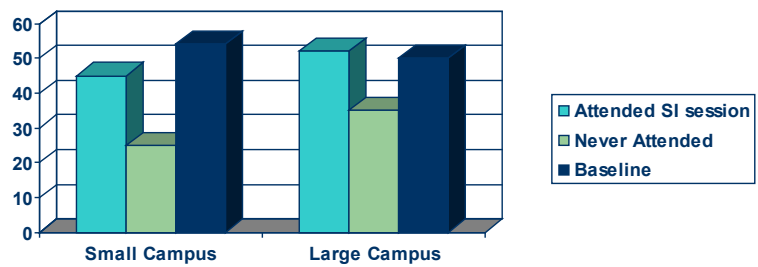
In 2001, one of the smaller campuses at Valencia, at which the lead author (Julie Phelps) serves as SI faculty liaison, began providing SI sessions in four mathematics courses. During the Summer of 2002, the campus administration believed that if a faculty member were trained for the program, s/he would have ownership, and the program would grow and adapt to the culture of the college campus. Thus, the SI program was piloted. Simultaneously, the largest campus identified a need to develop student success and retention in the first two levels of mathematics and applied for a strategic budget initiative to implement SI. The program was funded as a two-year pilot program and began in fall 2003. After two years, the program was considered successful. Other campuses are currently looking at SI as a way to foster student retention and success.

Piloting SI in developmental mathematics at Valencia

In 2004, Valencia identified its ten least successful courses. Of them, seven were in mathematics. Of those seven, four were developmental. Thus, an undeniable need existed for developing innovative strategies to create a climate of achievement for learners in developmental mathematics. SI was piloted in selected sections of developmental mathematics courses. Analyses of GPA and success rate were computed for students who attended the SI session at least once, those who never attended an SI session, and those in a similar group of students with the same set of instructors yet without the support of SI sessions.

Derived from two of Valencia's six campuses—one, a small campus (1,800 students); the other, a large campus (12,000 students)—analysis of 2004 data supports use of SI in developmental and pre-collegiate

Graph 1. MAT0012: Percent success rates of students in pilot study.



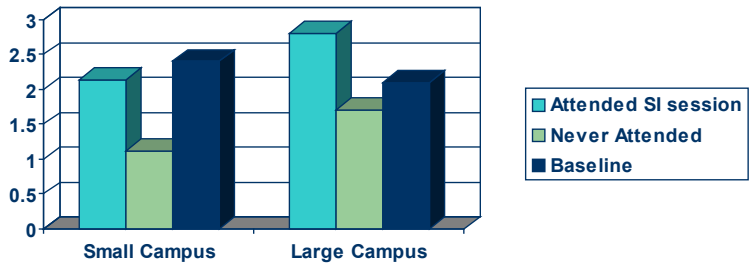
level mathematics. Graphs 1 and 2 show the preliminary findings from a pilot program of SI, which has produced promising results on the large campus for MAT0012.

At the conclusion of the Fall '03, Spring '04, Summer '04, and Fall '04 terms, students who attended SI sessions for MAT0012 on the large campus had an overall course GPA of 2.8 compared to a 1.7 course GPA for students who did not participate in SI sessions. At the large campus, the control group for MAT0012 had an overall GPA of 2.1 (see Graph 2). The piloted sections reported a 52 percent completion rate for students attending SI sessions compared to a completion rate of 35 percent for students who did not attend. On the large campus, the control group for MAT0012 had a course completion rate of 54 percent (see Graph 1).

Graphs 1 and 2 also include preliminary results for MAT0012 on the small campus. At the conclusion of the Fall '03, Spring '04, Summer '04, and Fall '04 terms, students who attended SI sessions for MAT0012 on the small campus had an overall course GPA of 2.13 compared to a 1.125 course GPA for students who did not participate in SI sessions. At the small campus, the control group for MAT0012 had an overall GPA of 2.4 (see Graph 2). The MAT0012 pilot sections reported a 45 percent completion rate for students who attended SI sessions compared to a completion rate of 25 percent for students who did not attend. On the small campus, the control group for MAT0012 had a course completion rate of 50 percent (see Graph 1).

Graphs 3 and 4 indicate that the preliminary findings from piloting SI in MAT0024 on the large campus are also promising. At the conclusion of the Fall '03, Spring '04, Summer '04, and Fall '04 terms, students who attended SI sessions for MAT0024 on the large campus had an overall course GPA of 2.57 compared to a 2.22 course GPA for students who did not participate in SI sessions. On the large campus, the control group for MAT0024 had an overall GPA of 2.1 (see Graph 4).

Graph 2. MAT0012: Grade point average (GPA) of students in the pilot study.



The piloted sections reported a 54 percent completion rate for students who attended SI sessions compared to a completion rate of 43 percent for students who did not attend. On the large campus, the control group for MAT0024 had a course completion rate of 45 percent (see Graph 3).

Graphs 3 and 4 also include the preliminary results for MAT0024 on the small campus. At the conclusion of the Fall '03, Spring '04, Summer '04, and Fall '04 terms, students who attended SI sessions for MAT0024 on the small campus had an overall course GPA of 2.67 compared to a 0.7 course GPA for students who did not participate in SI sessions. At the small campus, the control group for MAT0024 had an overall GPA of 2.3 (see Graph 4). The MAT0024 pilot sections reported a 63 percent completion rate for students who attended SI sessions compared to a completion rate of 15 percent for students who did not attend. On the small campus, the control group for MAT0024 had a course

Chart 3. MAT0024: Percent success rates of students in pilot study.

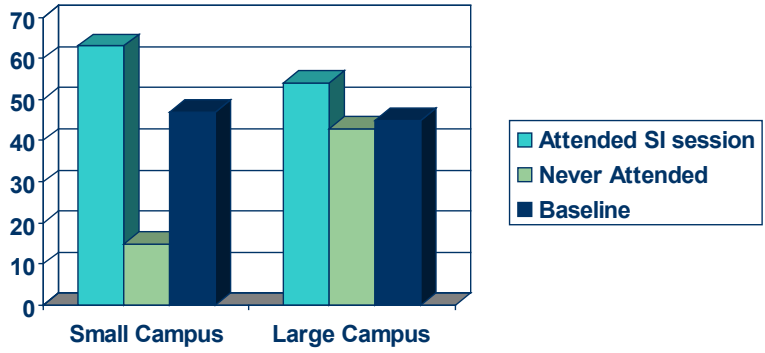
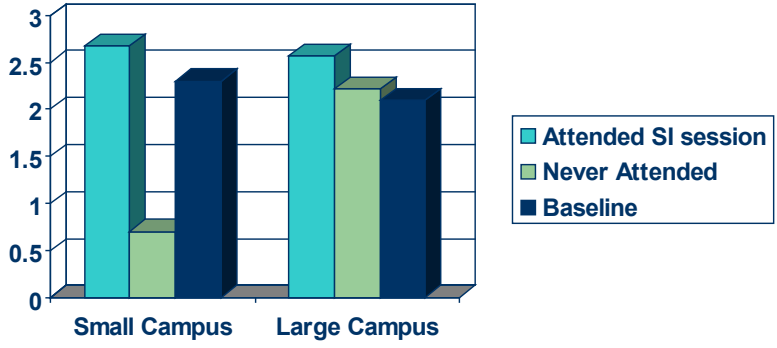


Chart 4. MAT0024: Grade point average (GPA) of students in the pilot study.



completion rate of 47 percent (see Graph 3).

The pilot study on the large campus was only for MAT0012C and MAT0024C; thus, there was no data reported for MAT1033. However, the small campus did pilot SI in MAT1033. The preliminary results for MAT1033 on the small campus are shown in Graphs 5 and 6.

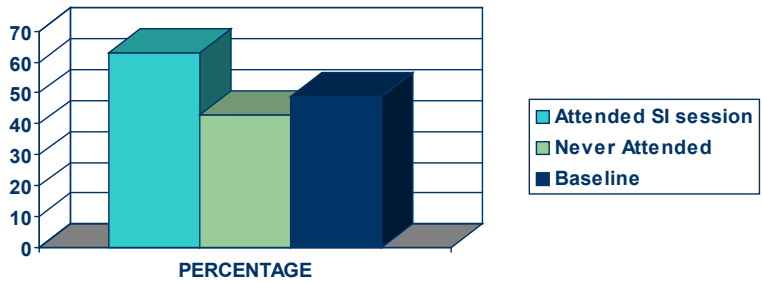
At the conclusion of the Fall '03, Spring '04, Summer '04, and Fall '04 terms, students who attended SI sessions for MAT1033C on the small campus had an overall course GPA of 2.76 compared to a 1.7 course GPA for students who did not participate in SI sessions.

Campus data concerning MAT1033 yielded an overall GPA for the control group of 1.98 (see Graph 6). The MAT1033C pilot sections had a 63 percent completion rate for students who attended SI sessions compared to a completion rate of 43 percent for students who did not attend. On the small campus, the control group for MAT1033 had a course completion rate of 49 percent (see Graph 5).

When comparing student results from the Pre-Algebra (0012) courses (students who attended SI sessions vs. the control group), findings were not significant at the $\alpha = .05$ level; however, statistical significance was achieved for the data collected in Beginning and Intermediate Algebra (0024 and 1033, respectively). Additional findings, which were based on qualitative feedback from SI participants at the large campus, include the following:

1. Students reported a higher level of confidence in their abilities.
2. Students reported a lower level of test anxiety related to college preparatory math. Finally, an interesting observation was that a student who participated more than the average (6 times) in the SI instruction sessions received an "A" or "B" grade 35.5 percent more often.

Graph 5. MAT1033C: Percent success rates of students in small campus pilot study.



Recommendations

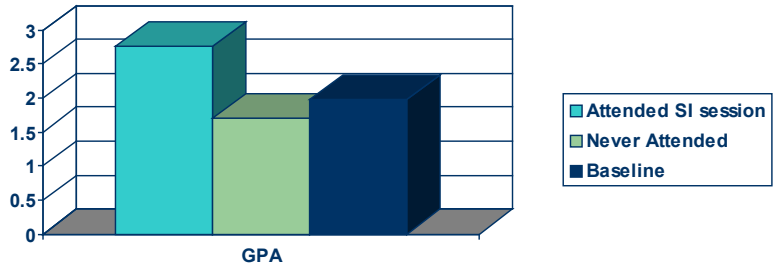
Beyond achievement of statistical significance in examination of quantitative data, however, further areas of qualitative research inquiry are needed. Relevant research questions include the following:

1. What are the underlying themes of *student motivation* in attending SI sessions that are associated with community college developmental mathematics courses?
2. What *learning experiences* of students who attend SI sessions are associated with community college developmental mathematics courses?

Empirical studies that ask these research questions, among others, of SI participants can do much to ensure that learning is enhanced and facilitated in developmental mathematics courses in the community college for "at-risk" students. Preliminary findings from descriptive research at Valencia Community College, Orlando, Florida, encourage researchers to further examine the utility of SI in creating a climate of achievement for these learners.This pilot study of SI in developmental mathematics at two campuses provides findings consistent with the literature regarding the positive effect of such instruction. It is important to note that a majority of empirical studies involving SI are based on outcome measures (e.g., GPA and overall success rates) and Likert scale satisfaction ratings. Consequently, there is a paucity of research in the contemporary literature that addresses what students actually experience during SI instruction.

Many existing studies also fail to provide insight into what motivates students to attend SI sessions. Educators, especially those in U.S. learning-centered institutions such as community colleges, need to discover what factors motivate and sustain students who seek assistance in difficult and/or "high-risk" courses. As a follow-up to this research regarding use of SI in developmental and pre-collegiate mathematics, Julie Phelps is conducting an in-depth phenomenological study at Valencia to

Graph 6. MAT1033: Grade point average (GPA) of students in the small campus pilot study.



examine the experiences of participating students and leaders during SI sessions.

Conclusions

"At-risk" students have increased, and that label now describes the majority of students in American community colleges. Educators need to continue exploring retention strategies that support learning-centered instruction, especially as it pertains to learners who often enroll in developmental courses. Supplemental Instruction is one of many programs that have shown tremendous promise as a mechanism for establishing a climate of achievement for at-risk learners. In discussing the value of SI, Arendale (2003) reported the following:

> After a rigorous review process in 1981, the SI Program was designated by the U.S. Department of Education as an Exemplary Educational Program. SI was the first of only two programs validated by USDOE as improving student academic achievement and graduation rates. Faculty and staff from more than 1,000 institutions in 13 countries have received training to implement SI. (para. 3)

Historical definitions of "at-risk" students have tended to focus on observable characteristics—race, ethnicity, socioeconomic standing, and status within the institutional setting. The American Association of Community Colleges (AACC) (as cited by Perez, 1998) suggests a more functional definition of "at-risk," one that describes the relations between the resources a student brings to the educational experience and the demands the educational program makes on the student.

Developed in 1973, Supplemental Instruction has gained recognition as an academic support program that produces demonstrable results in student performance, retention, and academic success. Studies suggest SI improves the grades of minority, non-traditional, low-risk, and high-risk students (Congos & Schoeps, 1993; Wolfe, 1998). In addition, SI offers a curricular venue that mitigates factors known to impede learning: adjustment, isolation, difficulty, and incongruity. SI also uses academic group work to build bonds between students (Wolfe, 1998) and to create a climate of achievement.

Almost half of all students who enter community colleges need at least one remedial course, which is often developmental mathematics. Preliminary findings from descriptive research on the use of SI in developmental mathematics courses at Valencia Community College are consistent with the current body of literature. With an increasing number of states mandating remediation as the sole responsibility of community colleges, the potential benefits of Supplemental Instruction in this institutional setting cannot be over emphasized.

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