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TEACHERS COLLEGE, COLUMBIA UNIVERSITY

Computer-Mediated Developmental Math Courses in Tennessee High Schools and Community Colleges: An Exploration of the Consequences of Institutional Context

Maggie P. Fay

February 2017

CCRC Working Paper No. 91

Address correspondence to:

Maggie P. Fay
Research Associate, Community College Research Center
Teachers College, Columbia University
525 W. 120th St., Box 174
New York, NY 10027
212-678-3091
Email: mf2812@tc.columbia.edu

Funding for this research was provided by the Bill & Melinda Gates Foundation.

Abstract

Assignment to remediation in college poses a significant barrier to degree attainment. Computer-mediated delivery of remedial mathematics shows promise as a means of enabling students to accelerate through math remediation and become college-ready. In Tennessee, this type of reform was for some time offered as a course to both high school and college students. Yet the high school students were much more likely to complete the course in one semester. This study makes use of site visit data collected at three community colleges and four high schools in Tennessee in 2015 to explore how the institutional context of the high schools compared with that of the colleges in ways that may have affected the implementation and efficacy of computer-mediated mathematics. Broadly, the high schools maintained structures and enacted classroom practices to foster student success under the premise that such students are unlikely to have autonomous, self-directed study habits. Community colleges, on the other hand, generally sustained policy and practice based on the notion that a community college student is autonomous and self-regulated.

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1. Introduction

Large numbers of students in the United States graduate from high school and enroll in college only to discover that they are not deemed ready for college-level coursework. Sixty-eight percent of new high school graduates who enroll in community colleges and 40 percent of those who enroll in open-access four-year colleges are referred to developmental (or "remedial"[1]) coursework, typically by virtue of a low score on a placement test (U.S. Department of Education, National Center for Education Statistics [NCES], 2013).[2] Students who are referred to developmental courses in math or English are much less likely to earn a college credential than are those who place into college-level courses. The math content area is of particular concern. Fifty-nine percent of community college students place into one or more developmental math courses, but only 33 percent of these students complete their developmental coursework and move on to college-level math (Bailey, Jeong, & Cho, 2010).

In recent years, many colleges and college systems have undertaken reforms in their developmental math offerings to improve student learning and outcomes. One approach involves offering developmental math content to high school seniors who need help to become college ready by graduation. Another approach involves the use of computer-mediated developmental math—a redesigned version of traditional developmental math that employs instructional technology in an effort to speed up course completion and improve student learning. In Tennessee, these approaches have been combined.

For some time, Tennessee offered the same developmental math curriculum to high school and college students, called Seamless Alignment and Integrated Learning Support (SAILS) at the high schools and designated Learning Support Mathematics (LSM) at the colleges. From fall 2012 through summer 2015, this math curriculum, organized into five topical modules and delivered via computer-mediated format, was

[1] I use the two terms *developmental education* and *remedial education* interchangeably.

[2] Students are placed into remedial courses in math or English when they are deemed not prepared to engage in college-level coursework, as evidenced by a low score on a college placement test or other measure. Usually, students must complete their remedial requirements in math or English before moving on to college-level coursework in the same subject area.

used for both high school and community college students throughout the state.[3] Yet, according to fall 2014 data CCRC researchers collected from a subset of high schools and colleges in the state, the high school students had course completion rates that were between 14 and 29 percentage points higher than the college students.

The current research seeks to explain this difference. I and other CCRC researchers conducted site visits in summer and fall of 2015 to speak with college and high school personnel and students and to observe classes. Based primarily on that fieldwork and assisted by relevant research literature, this paper explores how differences in institutional structures and culture may have affected the implementation and efficacy of the computer-mediated developmental courses. I find that the high schools and colleges approached their student constituents with different expectations of student autonomy. The high schools had more robust structures and strategies in place to manage student behavior and to encourage student compliance with the goals of the SAILS course. I thus conclude that the degree to which an institution seeks to manage student academic behaviors likely has a substantial impact on student performance in computer-mediated developmental courses.

2. Potential Benefits and Pitfalls of Computer-Mediated Developmental Math

In response to low levels of college readiness upon high school graduation and poor completion rates in developmental math sequences, the K-12 and postsecondary sectors have implemented a host of reforms aimed at helping students become college ready. One such reform is the computer-mediated delivery of developmental math courses. The use of instructional technology to improve student performance in remedial coursework is part of a larger trend that seeks to shorten the amount of time that it takes to complete developmental requirements (Center for Community College Student Engagement, 2016). Computer-mediated instruction can take a range of forms, combining computer-mediated learning with traditional teacher-led, lecture-based

[3] In fall 2015, the 13 community colleges in Tennessee implemented corequisite remediation at scale for math, writing, and reading (see Belfield, Jenkins, & Lahr, 2016). The SAILS course is still used in the state's high schools.

instruction in differing proportions. The type of computer-mediated course examined in this study in both the SAILS and LSM course is a “hybrid emporium” model, referred to throughout the paper as a hybrid model, in which students attend regularly scheduled classes where they work independently at computer stations. Students learn mathematical topics from software that provides quizzes, tests, and problems sets, and they are offered instructional support such as video tutorials, help features, and access to digital textbooks. In addition, they receive one-on-one support from instructors in the classroom.

There are a number of potential advantages to learning within computer-mediated learning environments which may facilitate accelerated student progress in these types of courses. Students spend more time doing math problems as opposed to their more passive participation in a lecture-based class environment (Twigg, 2011). Computer-mediated formats afford greater flexibility, allowing students to work at their own pace and spend more time on topics they know less well (Downing & Gifford, 1996; Goldschmid & Goldschmid, 1973). Computer-mediated instruction provides greater “personalization” as the software identifies students’ deficiencies in math knowledge, allowing them to skip portions of the curriculum where they have demonstrated mastery. It also delivers immediate feedback on students’ work and provides individualized study plans (Twigg, 1999). Instructional software supplies a practically infinite bank of problem sets and worked examples for students (Bickerstaff, Fay, & Trimble, 2016) and frees course instructors from lecturing, thereby enabling them to provide one-on-one support (Barnett, Fay, Pheatt, & Trimble, 2016). The benefits of using instructional software seem to be particularly germane to developmental math students, who might profit from individualized attention and the opportunity to spend more time brushing up on material that they may have forgotten or never fully mastered.

However, in practice, research shows that computer-mediated developmental math courses may pose barriers to community college students’ progress through developmental math courses. For example, the Virginia Community College System (VCCS) implemented computer-mediated developmental math courses as part of a host of reforms intended to improve student completion rates in developmental education starting in 2010 (Bickerstaff et al., 2016). In the fall of 2012, 2,399 VCCS students enrolled in computer-mediated courses in which they had to complete four modules to satisfy their developmental math requirements. At the end of the fall semester, 83 percent of students had failed to complete the four-module sequence; over half of those (42 percent) had completed zero modules (Bickerstaff et al., 2016). Poor completion rates in computer-mediated courses at the college level may be due to the course administration that is used, which may allow for looser deadlines and self-pacing on the part of students (Kulik, Kulik, & Bangert-Drowns, 1990). The greater independence afforded by this structure can also pose challenges to student progress, particularly for developmental students who may lack well-developed academic self-regulation including motivation, time management, and organizational skills required to remain on schedule (Bickerstaff et al., 2016).

3. Computer-Mediated Developmental Mathematics in High Schools and Colleges: Differences in Per-Term Course Completion Rates in Tennessee

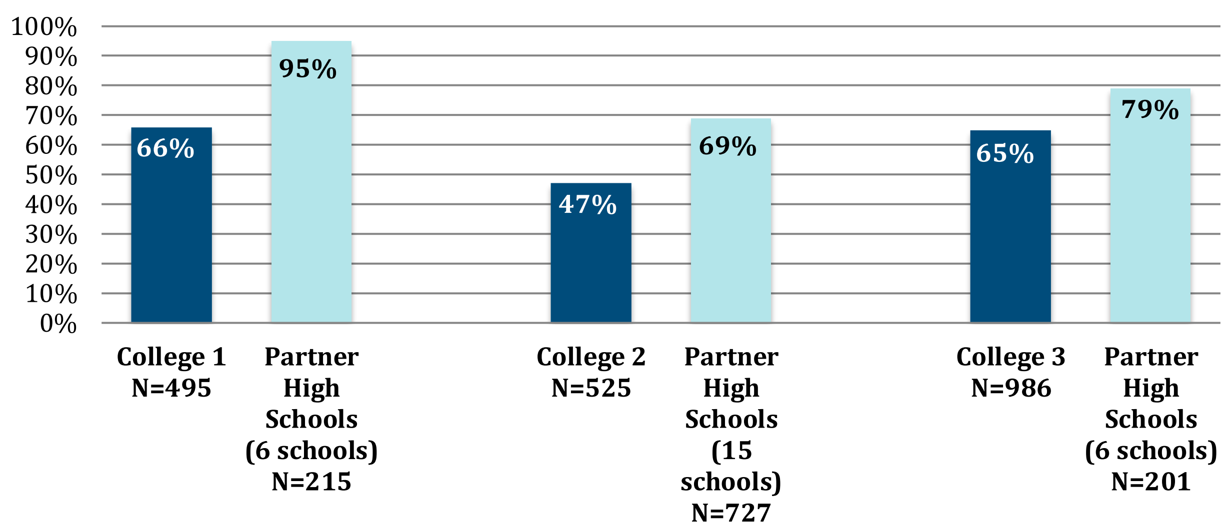
Remedial math courses are traditionally offered to students in college, but in a few states computer-mediated developmental math is offered to high school seniors. These courses, which enroll seniors who have tested "not college ready" on eleventh grade assessments, have shown promising results, enabling large numbers of high school students to complete their developmental math requirements and enter college ready for college-level math (Lederman, 2016). As a notable example, the Seamless Alignment and Integrated Learning Support (SAILS) program in Tennessee offers the community college developmental math curriculum to high school seniors. Across high schools and community colleges, students who take developmental math—SAILS at the high schools and LSM at the colleges—use the same curriculum delivered via the same computer-mediated model.

The high school students demonstrate much higher course completion rates than the college students. Figure 1 compares the completion rates of entering developmental students at three community colleges in Tennessee with students at high schools that function as feeder schools to these colleges.[4] The figure displays the percentage of LSM-

[4] The figure is based on aggregated student-level course completion data we received for each college that we visited in this study, and for the feeder high schools in the SAILS program.

enrolled students in community colleges who completed all five modules of the course in the fall semester of 2014, compared with the proportion of SAILS-enrolled high school students who completed the course in the same semester. It is important to recognize that the completion rates shown in the table do not control for any student characteristics. The students in high schools were certainly younger on average than the college students, and I assume that they spent less time working at jobs than the community college students. While there is no reason to suspect other strong dissimilarities (both groups were deemed "not ready for college-level coursework in math," albeit through different assessments), I cannot determine with the available data whether there might have been other differences between the two groups in terms of demographic and background characteristics, prior academic achievement, and motivation.

Figure 1
Fall Semester 2014 High School and College Five-Module Course Completion Rates



Note: These statistics are purely descriptive; analyses did not control for any student characteristics.

Nonetheless there are dramatic differences in one-semester course completion rates across the high school and community college contexts. High school students were between 14 and 29 percentage points more likely to complete the course in a single semester. It thus seems reasonable that differences in institutional context that affected how the course was administered may account for some of the difference in the completion rates.

4. Literature Review: Online Coursework and Self-Regulatory Skills

4.1 Student Outcomes in Online and Hybrid Courses

Virtually all the research about online learning, including hybrid course models, agrees on one point: Online learning is growing quickly in both the K-12 and the postsecondary sectors (Allen & Seaman, 2010; Christensen, Horn, & Johnson, 2008; Means, Bakia, & Murphy, 2014; Miron & Gulosino, 2016). Thus, it is likely that current secondary and postsecondary students either have already taken or will take an online course at some point in their academic careers. Fully online courses do not require students to attend classes in a brick-and-mortar location, and they are often asynchronous, allowing students to login to complete coursework at their convenience. Due to the flexibility that they offer for scheduling, the growth of online course offerings has been particularly strong in community colleges, which enroll larger numbers of older students who frequently need to balance their studies with job and family responsibilities (Means et al., 2014; Xu & Jaggars, 2013). The largest area of growth for online courses in the K-12 sector has been in high schools for students who have failed courses and who need flexible options for credit recovery (Means et al., 2014).

An important impetus for the expansion of online learning is the notion that the individualized and student-directed learning that computer-mediated interventions can facilitate provides a higher quality learning experience than face-to-face instruction (Jaggars & Bailey, 2010; Means et al., 2014; Twigg, 1999). It is theorized that online learning may address persistent achievement gaps between disadvantaged and non-disadvantaged student populations, such as gaps in graduation rates and rates of college readiness, by enabling students to control the pace at which they move through the material, and by allowing students to choose among a variety of pedagogic approaches to best suit their learning needs (Twigg, 1999; Means et al., 2014). Further, online learning expands access to advanced coursework for under-resourced urban and rural schools, and it provides greater flexibility for students attempting to balance studies with family and job responsibilities (Staker & Horn, 2014; Means et al., 2014).

At the same time, empirical evidence suggests that students demonstrate better outcomes in face-to-face courses than in *fully online* courses (in contrast to outcomes in *hybrid courses*, which are discussed below) (Bernard et al. 2004; Cavanaugh, Gillan, Kromrey, Hess, & Blomeyer, 2004; Jaggars & Bailey, 2010; Means et al., 2014; Zhao, Lei, Yan, Lai, & Tan, 2005). A number of meta-analyses on the effectiveness of fully online versus face-to-face courses have shown no difference in student learning (measured by course grades and assessments) between the two delivery models for those who complete the courses (Bernard et al., 2004; Cavanaugh et al., 2004; Jaggars & Bailey, 2010; Means et al., 2014; Zhao et al., 2005). However, several studies suggest that online courses have significantly higher withdrawal rates than face-to-face courses (Jaggars & Bailey, 2010), particularly among students with weak academic skills, such as developmental education students (Summerlin, 2003; Xu & Jaggars, 2013).

A few studies have investigated how learners with different characteristics perform in online versus face-to-face courses (Xu & Jaggars, 2011; Xu & Jaggars, 2013). This research suggests that male, Black and Latino, younger, and less well-prepared students perform particularly poorly in fully online courses, with lower course grades and higher withdrawal rates than in face-to-face courses (Xu & Jaggars, 2013).

Performance gaps that exist in face-to-face classrooms appear to be exacerbated in fully online environments (Bork & Rucks-Ahidiana, 2013; Xu & Jaggars, 2013). Low-income, academically underprepared students and students of color may benefit from the physical presence of an instructor (Means et al., 2014), and the type of structure provided in face-to-face course models, which usually includes a full-class lecture format and the immersion of students into a cohort of classroom learners (Bickerstaff et al., 2016). Indeed, research suggests that students need well developed "self-regulatory" skills in addition to content knowledge to succeed in online courses (Bickerstaff et al., 2016; Bork

& Rucks-Ahidiana, 2013; Liu, Gomez, Khan, & Yen, 2007; Lynch & Dembo, 2004; Means et al., 2014), and that students with weaker academic preparation tend to have poorer academic self-regulation (Bailey, Jaggars, & Jenkins, 2015; Jaggars & Bailey, 2010). It may thus be the case that students whom one might think could benefit the most from the flexibility and the student-directed nature of online learning interventions—students with weaker academic preparation and those attempting to balance studies with other priorities—are those who perform least well in fully online courses.

In contrast to the findings on fully online courses, research on hybrid courses has shown that they result in more positive outcomes for student learning when compared with fully online and face-to-face courses (Means et al., 2014; Means, Toyama, Murphy, Bakia, & Jones, 2009). The "hybrid" model encompasses a wide range of interventions that merge computer-mediated instruction with "traditional" teacher-led instruction (Picciano, Dziuban, & Graham, 2014). Many hybrid models, including the model examined in this study, deliver course content primarily through instructional software, but they also include the presence of an instructor in the classroom to provide one-on-one, face-to-face instruction in a bricks-and-mortar location (Staker & Horn, 2014).

Hybrid courses appear to have more "equitable" enrollment and persistence patterns than fully online courses. Xu & Jaggars (2011) found no systematic differences between the characteristics of students who enrolled in hybrid versus face-to-face courses, and also no difference in completion rates between the two course models, even among student subgroups. Thus, hybrid courses are not associated with higher withdrawal rates characteristic of fully online courses. Hybrid models are sometime called "the best of both worlds" because they capitalize on the strengths of online instruction—greater differentiation of instruction and increased learner control—and on the strengths of traditional classroom approaches with guidance and support provided by a teacher (Christensen, Horn, & Staker, 2013).

In sum, hybrid course models appear to have better learning outcomes than face-to-face or online courses (Means et al., 2009; Means et al., 2014), without the higher withdrawal rates that characterize fully online courses (Xu & Jaggars, 2011). Further, they do not appear to exacerbate achievement gaps that exist in face-to-face classrooms as online courses do (Xu & Jaggars, 2013). However, because of required "seat time," they do not provide the flexibility and the increased access of fully online courses (Jaggars & Bailey, 2010).

The literature on student performance in hybrid courses may provide some insight into the high developmental math completion rates by the Tennessee high school students examined in this study. The strong performance of the high school students in a hybrid course is supported by the literature, which shows that hybrid models can facilitate stronger learning outcomes than either face-to-face or fully online courses. However, the literature does not help to explain why the college students, using the same curriculum and delivery model, had much lower completion rates than the high school students. To explain this, I draw on literature on academic self-regulation and the role that self-regulation may play in successful engagement in computer-mediated courses.

4.2 Self-Regulatory Skills and Success in High School and College

Research on student academic performance suggests that "non-cognitive" or "non-academic" skills play a critical role in student achievement (Bailey et al., 2015; García, 2014; Heckman & Rubenstein, 2001; Karp & Bork, 2014; Zimmerman, 2002). One umbrella term for non-cognitive skills is academic "self-regulation." Self-regulation includes a range of behaviors that facilitate academic success, such as time-management, self-efficacy, motivational, and help-seeking behaviors (Bailey et al., 2015; Karp & Bork, 2014; Zimmerman, 2002).

Due to their individualized and self-paced design, online and hybrid courses require students to have strong academic self-regulation to be successful (Bickerstaff et al., 2016; Hare-Bork & Rucks-Ahidiana, 2013; Liu et al., 2007; Means et al., 2014; Lynch & Dembo, 2004). However, institutional context may play a role in the extent to which self-regulatory skills are needed for success in hybrid courses: the institutional structure, practice, and culture within which hybrid courses operate might serve to either compensate for or exacerbate weak self-regulation.

Postsecondary educational institutions assume higher levels of student autonomy than K-12 institutions and consequently have less rigorous structures in place for the oversight of student behavior and work (Bailey et al., 2015; Karp, 2012). Karp and Bork (2014) found that the postsecondary environment requires students to develop more self-directed and autonomous learning habits to be successful. The authors observed that: "Successful college student role enactment entails academic habits that are more independent, reflective, and self-initiated than are [high school] student roles" (p. 15). In order to transition to become successful college students, high school students must learn to rely less on external supports and structures, and instead draw on internal resources of academic self-regulation (Karp & Bork, 2014).

In contrast, high schools may enable students to succeed academically with weak self-regulatory skills through the provision of more academic supports and through more active monitoring and management of student work (Bailey et al., 2015; Karp, 2012). In general, high schools do not anticipate strong academic self-regulation capacity on the part of their students, and they therefore intercede in a multitude of ways to manage student conduct. For example, high schools students have rigid daily academic schedules, and highly regulated and enforced attendance requirements. And in their coursework, high school students tend to receive, in comparison to college students, shorter-term assignments, more frequent feedback from instructors, and more frequent reminders and monitoring to help them comply with course deadlines (Bailey et al., 2015; Dickie & Farrell, 1991; Karp & Bork, 2014).

5. Setting for the Research

The research we conducted took advantage of a unique opportunity created by a convergence of postsecondary education and secondary education reforms in which essentially the same course was offered simultaneously in high schools and community colleges in Tennessee. Learning Support Mathematics (LSM) is a community college course based on the Tennessee Board of Regents' (TBR) learning competencies for developmental math, which define the knowledge that students must master to be deemed college-ready. Seamless Alignment Integrated Learning Support (SAILS) math employs exactly the same course content and hybrid delivery model as LSM, though, as our examination will show, the courses have been implemented by their institutions with important differences. SAILS math is offered in many Tennessee high schools to students who test as not college-ready in math during the eleventh grade.

In 2010, the TBR mandated that all thirteen Tennessee community colleges implement LSM to reduce to the amount of time that students spend completing remedial math requirements (Crandall & Soares, 2015). Traditional, semester-long developmental course sequences had taken students with high remedial needs a minimum of three semesters to complete. The LSM curriculum—which is no longer used by the colleges as the primary model for developmental assistance[5]—was designed to enable students to complete all developmental math in a single semester.

While colleges were given discretion over how to implement reforms to meet the LSM course guidelines, they were required to implement redesigns in developmental math that combined technology-driven interventions with student-centered learning (Tennessee Board of Regents, 2010). All of the colleges converged around a similar model: a curriculum consisting of five modules delivered via a hybrid computer-mediated format. During the period when LSM was employed by the colleges (fall 2010 through summer 2015), enrolled students were required to attend regular classes on campus. During class, they worked independently at computer stations, completing the curriculum via instructional software with teacher support.

The SAILS and LSM modules may contain a pretest, problem sets, quizzes, and a post-test. Students must master a specified set of learning competencies before moving on to the next module. The table below provides an overview of the content covered.

Table 1
Topics of Modules Used in SAILS and LSM Developmental Math

Unit Number	Topic
1	Real Number Sense and Operations
2	Operations With Algebraic Expressions
3	Analyze Graphs
4	Solve Equations
5	Modeling and Critical Thinking

Note. Source: Chattanooga State Community College (2013).

[5] The state of Tennessee no longer offers a standalone Learning Support Math course to community college students. The Tennessee community colleges moved to a corequisite model for developmental education in the fall of 2015, in which students who test not-college-ready are placed directly into college-level courses with additional academic support. The data examined in this paper were collected before the switch to the corequisite model occurred.

In 2012, Chattanooga State Community College, which created SAILS, began offering the SAILS course to their feeder high schools, taught by high school faculty. SAILS then expanded to other high schools through other Tennessee community colleges.[6] At both the high school and college level, students who completed all five modules were considered college-ready in mathematics at any public Tennessee college or university. Essentially, SAILS students were enrolled in the partner community college's LSM course, which was delivered remotely on high school campuses.

6. Data Collection and Methods

The circumstances of the developmental math reforms in Tennessee provides an opportunity to compare the implementation of what amounts to the same developmental math course, delivered via a hybrid computer-mediated model, implemented under two different institutional contexts. The situation allows for an examination of how the policies, practices, and social organization at the high schools and the community colleges may influence stakeholder experiences and student outcomes in the course. Of particular interest is whether and how much institutions sought to actively manage student behavior in the course in order to fulfill the course goals, or whether they instead relied more heavily on student academic self-regulation to facilitate course completion.

The research questions for this study are:

1. How is a hybrid computer-mediated developmental math course implemented in the high schools and community colleges?
2. To what extent does institutional context (structures/policies, classroom practices) differ in the two settings? How does this influence the implementation of the hybrid computer-mediated developmental math course in the high schools and colleges?

[6] The SAILS course is still used in high schools.

3. What institutional factors might contribute to the much better course completion rates in the high schools versus the colleges?

To address these questions, qualitative data were collected in the summer and fall of 2015 during site visits to three community colleges and four high schools in Tennessee. As all community colleges in the Tennessee system offered LSM, colleges were selected for participation in the research based on their willingness and ability to host researchers for a day-long site visit. Data collection consisted of semi-structured interviews with administrators, including math department deans and directors of developmental studies programs, LSM instructors and tutors, student support staff such as directors of tutoring and academic support centers, and of focus groups with students enrolled in LSM courses. We also observed at least one LSM class at each college to learn about approaches to instruction and to observe interactions in the classroom.

High schools were selected for participation in the research based on their partnership with the colleges that we had visited during the summer. My CCRC colleagues and I wanted to observe high school SAILS courses that most closely resembled the LSM courses offered in the colleges; by conducting fieldwork at colleges and their partner high schools, we ensured that the curricular content and student performance standards would be identical across the institutions. Fieldwork in the high schools consisted of semi-structured interviews with principals, SAILS instructors, math department chairs, district-level math coordinators, and SAILS coordinators, and of focus groups with students who were enrolled in SAILS math. Additionally, we observed one to three classes at each high school.

Interview questions at both the high schools and colleges were designed to provide data on how courses were implemented, and on how students experienced hybrid computer-mediated developmental math classes. The inquiry focused on the ways in which implementation of these courses varied across high schools and colleges, particularly with respect to stronger and weaker emphases on classroom regulatory structures, social norms, and how these variations might have affected implementation and stakeholders' experiences as well as student outcomes in the courses.

7. Findings

Analyses of the qualitative data reveal two categories of factors underlying differential student completion rates in the course across high schools and community colleges: institutional structural factors and institutional cultural factors. Structural factors are rules, policies, and other explicitly codified expectations that are created and enforced through formal processes. Structural factors include the strength of attendance policies, the amount of time students spend in class, the requirements for course completion, and the role that the SAILS coordinators play in supporting the implementation of the SAILS course. Cultural factors are norms and institutionally held expectations that are not explicitly dictated by the institution but that are nonetheless maintained through non-formal processes such as social pressure. Cultural factors include expectations for work that students will complete independently, students' perceptions of the course; student motivation and the extent to which the institutions seek to manage student motivation to complete the course, and relational norms and strength of relationships. I examine these structural and cultural factors in the subsections that follow.

7.1 Structure: Attendance Policies

An important factor underlying student success in the course, according to numerous high school and college faculty and administrators is time on task, which is facilitated by course attendance polices. Despite the fact that the LSM/SAILS course was designed to be individualized, self-paced, and to allow for students to work remotely, both college and high school stakeholders emphasized that regular class attendance was critical to good performance, and they said that students did not typically work at the course outside of class. This may be due to the fact that students, particularly older students, encounter more competing demands for their time outside of class; students of all ages may have a greater tendency to procrastinate outside of class time, and may struggle to complete problems without instructor support.

In both the high schools and the colleges, administrators and faculty reported that the most common cause of failure in the course was poor attendance. The implementation of the course at the high school and college level included attendance expectations. In both contexts, instructors stressed the importance of punctuality and attendance, and students reported that they were aware of attendance policies and the consequences of not complying with them. However, high school attendance policies appear to have stronger "teeth" due to the fact that attendance is mandated by law and is tied to higher stakes outcomes for students and schools. One high school math department chair, who also taught the LSM course as an adjunct at a local community college, reported that attendance policies were a key factor in higher completion rates in high schools:

> Well because [high school students] have to be in class, their attendance [is stronger]. In college a lot of professors don't have attendance policies, nothing is really counted against you. [In high school], I mean, they have to [attend]. They get scholarships which depend on good attendance; their GPAs are affected by attendance; a lot more is on the line with high school versus college about attendance.

Consistent with the previous quote, college instructors reported that attendance policies were often not strict enough to affect students' grades, which weakened their ability to shape student behaviors. Moreover, high schools had one institution-wide attendance policy that administrators, faculty, and students knew, whereas colleges frequently did not have a standard institutional policy on attendance. Rather, polices depended on the department or course instructor. A dean of math and sciences at a college explained why the math department did not have a department-wide attendance policy:

> The math department has been hesitant to put that in place because we do have students who do fine without showing up, and they're able to excel. If we have a strict policy then people almost feel like they have to enforce it, and they can't make an exemption for a student who is just doing really well. And so, that hasn't come into place in the department.

This college's attendance policy is designed to accommodate a student who can perform well in a class without regular attendance. The archetypal college student for whom this policy, or in this case the absence of policy, is based, is an autonomous, self-regulated student. But as the college course completion rates suggest, many developmental students probably do not display these characteristics.

Staker and Horn (2014) observed that K-12 schooling serves a distinct social function from higher education. In addition to teaching students curricular content, K-12 institutions fill a custodial role, providing students with adult supervision while their parents or guardians are at work. The more potent and coherent attendance policies in high schools can be seen as a reflection of the custodial role of K-12 institutions. This does not mean that high schools do not have attendance issues. Indeed, many high school instructors reported that the most common cause of failure in the course was chronic attendance problems. However, in the high schools there was a clear and consistent expectation of strong student attendance, and there were significant consequences for missing class such as lowered grades, absent in many of the colleges.

7.2 Structure: Frequency of Classes

Another institutional structure that facilitated time on task for students was frequency of class meetings. Stakeholders observed that the daily schedule of class meetings in high schools benefitted student performance in a variety of ways. A significant driver of better completion rates in high schools may be the fact the high school students had, on average, more class time devoted to the course than college students. High school schedules varied, but of the high schools we visited, classes met five times a week for fifty minutes to an hour and twenty minutes daily. In contrast, in colleges the course met twice a week for an hour and twenty minutes per class.

A high school instructor reported that daily classes were an important reason for stronger course completion rates in high schools than in community colleges:

> I think because they have to meet daily and they're expected for an hour and 20 minutes to work on [the curriculum]. … They [high school students] come and they're already expected to [complete the course] so you know, why not do it while I'm here and not have to worry about it outside of here.

In addition to facilitating time on task, a high school math department chair noted that daily meetings led to the formation of stronger relationships between instructors and students:

> They are here five days a week, of course. In college you have three days a week or two days a week; you don't see

> them as often. … High school students, they are still kind of immature and they look up to the teachers. Sometimes they even look up to us as parents, versus in a college you don't see them as often. I don't think you can get the connection there as well.

In contrast to the situation at the high schools, college faculty observed that the less frequent class meetings of the course undermined student performance. As one college instructor reported:

> So one of the things that I see that's really working—that could be the reason that they [high school students] have a 99 percent [completion rate] is that teachers see their students every day. Every day for an hour, they see them every day. We don't. We see our students twice a week.

7.3 Structure: Course Completion Requirements

The high schools and colleges had significantly different requirements to obtain course credit, which likely influenced rates of course completion across the two contexts. Regardless of the setting, students had to complete all five modules to be deemed college-ready in math. In the high schools, students had to complete five modules to pass the course. However, in the colleges, students could pass the course by completing three out of five modules, and then re-enroll in a second semester to complete the remaining modules. Thus, success was defined differently at each institution.

An instructor at a college reported that he tried to conceal from students the fact that it was possible to pass the course by finishing three modules, as this undermined module completion rates:

> If you didn't communicate the possibility that that's all they had to do was the three, and pushed them to complete five, then I could see 55–65 percent of the students completing all five modules. But if you communicate up front, "Okay, here's all you have to do to pass the class," then that's what most students are going to aim for. A lot of them fall short because of that.

7.4 Structure: SAILS Coordinator

The SAILS coordinator serves as a liaison between the community colleges and high schools partnering with them. Their role is to support the high schools in implementing the course, and to ensure that the colleges' standards are maintained by the high schools offering their curriculum.

A large part of the SAILS coordinator's responsibility is to help high schools manage student pacing through the material to ensure that students complete the course on time. To do this, they generate weekly reports on student progress at each of the high schools they support, and they share these reports with school stakeholders. As one SAILS coordinator shared:

> So all the classes, I can see all of their grade books. I can see all the students. I see all of that. And I go through every week and I generate a report for them—active students, students that are behind, students that are ahead—all of that—where the students should be, where they are—so that's all electronic. I send that to the principals and their district person.

A potential barrier to student learning in individualized, self-paced, computer-mediated learning environments is that it can be harder to know when students are struggling with the material and when to provide needed support (Bickerstaff et al., 2016). By reviewing and communicating with schools about student performance data, the SAILS coordinators create more transparency around student progress. They become an extra person who is concerned with student success, sometimes directing teacher attention to a particular student or problem. As one SAILS coordinator noted:

> They're all in this class because clearly they're weak in math. Understandable, right? But if they can't dig themselves out then that would be a red flag. I hate to see kids take a test like seven times in a row without going back and reviewing or anything like that. And so that would be something that I might email a teacher about and say, "Hey, this kid's struggling. They've taken the test several times and they're not making it, you know. What's going on?"

The SAILS coordinators' role in facilitating communication may play an important part in the strong high school student completion rates. The elaborated communication helps to create a network of people inside and outside the school who are invested in student success, who can offer praise to successful students, and can assist or at least warn students who are struggling or lagging. One SAILS coordinator reflected upon the structure this way:

> So it helps to have a network and sort of a net to help the students that are falling behind and to help them make a plan for how they're going to finish. So that's really good. That's not just the teacher; that's kind of like a whole school.

Through the SAILS coordinator, the program creates an additional layer of monitoring of student progress and support for high school teachers that is absent at the college level.

7.5 Culture: Expectations for Independent Student Work

The institutional cultural factors, described in this and subsequent subsections, are not explicit policies dictating how the course ought to be implemented, but are collectively held perceptions and norms that influence the success of the course in each context. The first one I identify concerns the expectations for the amount of work students were expected to complete for the course independently. A number of faculty and administrators at the college level reported that an important difference in course implementation was the expectation for student work outside of class. In the high school SAILS courses, there was no homework assigned and no expectation that students would work through the curriculum independently. A college dean of developmental studies commented on the significance of this difference:

> High schools are not requiring these students to do homework. With college they have to do homework. They would not stay on track. The high schools expect them to do it all at school. They don't expect them to do anything at home. And that's hugely different.

High school faculty reported that, indeed, they did not expect their students to complete any homework outside of class. Most high school instructors created a schedule that allowed students to complete the five modules by working in class only, as one high school instructor described:

> We are not expecting them to do anything outside of the class. Inside the class, if they will do one lesson a day, like

> the video and the lesson that goes with it, then they will stay on track to finish. It's just those that get behind that we end up talking to the parent about the need to do some work outside class.

The majority of high school students reported that they did not work on the course outside of school. Those who did were highly motivated to finish in order to focus on other classes or priorities; these students thus benefitted from the self-paced structure of course.

In contrast, colleges expected students to work on assignments outside of class time. In some cases, expectations were high for the amount of time students would devote to the course independently:

> Well, we expect them to do at least three times [the amount of work they do in-class]. So if there is 6 hours that we're spending with the class, we'd like to see them do 18 hours overall. Now that's not going to happen in real life because people don't have 18 hours. But even if they got to 12 I'd be pretty happy.

At-home internet connection was cited as a problem for both high school and college students, as this college administrator observed:

> The computer-mediated approach is great if you own a computer, if you have Internet access. I think with our student body some people still do not have that convenience and so they get behind as a result.

For students who have computers and access to the Internet at home, there may still be barriers to completing homework. As one college student reported, there may be competing priorities:

> Right, because you're at home and you're watching the baby and then you finally get her to sleep and then you're like, "I need to do math right now since she's asleep," but you're like, "Well, I just had to watch her, then I have to watch her again. I have to do all this. I just want to sit here while she's asleep."

Obviously, the classroom environment strips down distractions for students, particularly students with families at home. College students noted that it was simply easier to procrastinate at home without the structures for productivity that the classroom provides: “It’s typical, because this is where we do not procrastinate here [in the classroom]; I procrastinate at home.” Additionally, students struggle to complete assignments at home because if they get stuck on a problem there may be only limited support available to them:

> Yeah, sometimes [I work on assignments] for 45 minutes to an hour at home if I can before I go to bed. I go over it, but like I said, I don’t have anybody to ask questions. If I have a problem and I get stuck, I try to work it out, but, you know, usually I’m exhausted.

7.6 Culture: Perceived Value of the Course Among Students

The high school students we spoke with mostly expressed positive sentiments about participating in the course because they believed it would help them to start college prepared, as these students reported:

> [Student 1]: Yeah, I thought it [SAILS course] was a great opportunity because I know that I’m not the best at math. So, just having this refresher, this class where I can a brush up on what I need to know [before] going on to college [is good], instead of going into Pre-Calculus or Finite Math or Statistics like everybody else did.

> [Student 2]: Right, in a remedial class [in college] you’re paying extra for it; it’s not really going to count for anything. But in high school we’re not paying for it. And it will help us in the long run to prepare for college. And then we even get to, you know, one up some of the other students by taking a college class if we finish it.

In contrast, college students enrolled in the course often felt like they were starting college already behind. The course costs college students time and money, but they do not earn college-level credits. As one college student said:

> But like I feel like [the LSM course] is a waste of time because it doesn’t really count towards your credits. Like you have the credit, but it doesn’t count. So it’s just like a waste of credits. I could have been taking real classes that would have given me [college-level] credits instead.

7.7 Culture: Facilitating Student Motivation

Due to the individualized, self-paced design of the course, maintaining student motivation was cited as a critical factor to student completion in both colleges and high schools. Motivation is an aspect of self-regulation (Zimmerman, 2002); many students may lack the motivation to complete five curricular modules without more proximate rewards along the way. An important difference underlying the success of motivational strategies across the contexts may be the extent to which each type of institution attempted to facilitate or increase motivation among students, or whether they regarded motivation as a quality that students should manage independently.

High schools took a more active approach to managing student motivation than the community colleges. As this high school principal explained, one of the important tasks of the course instructors was to motivate students:

> They [the instructors] know the math backwards and forwards, and they cheerlead. I mean, they are going to be positive with the kids, you know, when things get a little rough maybe, or a kid hits a wall. They are going to recognize it first and foremost. And they are going to be able to help them with it, second, and then they are going to try and convince the kid that "yeah you can do it," and "push through" and "let's keep going."

The principal observed that because the students in the course are weaker math students, they need more external support and reassurance that they can be successful. High school instructors and other staff had a larger repertoire of incentives at their disposal to maintain and foster student motivation, including pizza and ice cream parties, movie days, or allowing students who were ahead of the suggested time table for module completion to leave school early or arrive late depending on when the class fell in their schedules. For example, one high school instructor stated:

> I think the stickers really made a difference. Just kids getting excited about it, and that it compares them with everybody else. So everybody knows where they are. We tried at the end of each module they were on time to give them a party, some kind of free day, movies and cookies, or something like that.

Sticker charts were used in a number of the classrooms that we visited. Each time a student completed an assignment they were given a sticker to affix to the chart next to their name. As the teacher's quote above indicates, the sticker chart creates more transparency around student progress.

While college instructors attempted to enhance student motivation to complete the course, their incentive options were more limited and less effective. For example, instructors tried to motivate students to finish the course by reminding them that since the course was self-paced, those who worked hard and efficiently could complete early. One instructor said:

> But I let students know that they could complete the course a few weeks ahead of time. And then they don't have to come to class…They can focus more on their college-level classes that they are actually getting credit for. But you have some students that either don't listen or just make their mind up that they are not going to do work outside of class because they are not receiving actual credit for the class.

The opportunity to finish early may not motivate students who are not proficient enough in math to move quickly through the curriculum, regardless of the rewards.

7.8 Culture: Relationships

In high school, students are typically enmeshed in large and complex social networks, with connections to teachers, coaches, other students, and parents or guardians. High school personnel we spoke with frequently mentioned tapping other adults in students' lives to apply pressure on students who were not progressing through the course at a good pace, as this high school instructor describes:

> I've already called a couple of parents of students that have gotten behind. And it's not that it's a scare tactic, but it's to tell them if your child does not finish this class they're going to be with me again next semester. One of the students in here, I've notified his basketball coach, so he's been moving a lot faster than he had been.

Social networks also provide more opportunities to create consequences for inadequate performance. A SAILS coordinator reported that the program suggests that school personnel call parents and inform them of the stakes surrounding their child's successful completion of the course:

> And then getting the parents involved is a really good one. Because I think some teachers think, "Oh, it's a college class. I'm not allowed to contact parents." But we like to remind them, "No, they're still in high school. You can still contact their parents. Because this is still kind of a new thing and parents haven't heard of it or they don't realize that this could save their kid a thousand dollars, you know, once they go to college.

In contrast, in the community colleges, policy does not allow faculty and staff to call parents or other people in students' lives if their performance is suffering. This limits their options, as a college dean of math and sciences observed:

> We're not the parents. You know this is a community college. It's not K-12, so we can't have as much parental control over students' lives as we might like.

In addition to creating accountability for student performance in the course, relationships between students and instructors influence students' willingness to engage in help-seeking behaviors, another aspect of academic self-regulation (Zimmerman, 2002). Stakeholders in both contexts mentioned that the level of familiarity students had with instructors had an impact on their willingness to ask questions and seek help when they needed it. One college instructor noted that the continuity of relationships in high school could affect performance in the course:

> So the other thing is [high school teachers] have relationships with their students, historical relationships with their students that we don't have. From eighth grade, how many math teachers are there [in a secondary school]? I mean what, six? So we don't have those types of relationship because they see us for a semester, and then they are gone. So that could be another reason their success rates are so much higher.

Both high school teachers and students observed that strong one-on-one relationships between faculty and students were a feature of the social networks and of the culture of high schools in a way that was not true in community colleges. One high school instructor noted:

> Comparing high school to college from what I can remember, I think the difference—and this is no knock on the college professor—I think the high school teacher is more invested in making sure everyone succeeds and gets through the class whereas in my experience the college professor was there, they would teach [the material], well you might know what they were talking about, you may not. There wasn't that one-on-one where you feel like the teacher is invested to try to get you through. So I would say that might have something to do with the high school students doing better.

The social norms in college tend to encourage more autonomous and individual behavior on the part of students, and this seems to affect or to include the extent to which students are held accountable for their progress or lack of progress through the course. It also appears to influence students' willingness to seek help from instructors or others, which may affect how well they learn the course material. Students and instructors reported that students are more apt to seek out help from people who they know and with whom they feel comfortable.

8. Discussion and Conclusion

This research took advantage of a unique opportunity in Tennessee to compare implementation and student outcomes in computer-mediated developmental math courses offered simultaneously in community colleges (the LSM course) and high schools (the SAILS course. The curriculum, delivery format, and instructional software used in the LSM and SAILS courses were identical, but the courses were implemented with differences that significantly impacted student outcomes. High school students were between 14 and 29 percentage points more likely than college students to complete the course in a single semester. The effectiveness of the LSM/SAILS course appeared to depend on institutional context, that is, on how the high school and colleges implemented the course. This research sought to explore factors that may have contributed to the large differences in student outcomes.

At the crux of the differences across the high school and college contexts are distinct expectations for student autonomy and self-regulation, and differences in structural and cultural factors that reflect and buttress those expectations. The high schools had low expectations for student autonomy, and the structures and cultural practices of the high schools were designed to more intrusively manage student behaviors. The high schools had stronger attendance policies; they made use of daily class meetings; they sought to manage student motivation around the benefits of course completion and indeed required the completion of all five modules to pass the course. They also used social networks and had the benefit of a SAILS coordinator to create accountability for student performance.

In contrast, the colleges had high expectations for student autonomy and their ability to self-regulate. Consequently, the colleges had weaker structures and cultural practices for managing student behavior. Community colleges had less stringent attendance policies; they made use of less-than-daily class meetings; they did not require students to complete all five modules of the course in one semester; and they made weaker efforts to motivate students and monitor their progress. What is more, the college students appeared to be less internally motivated about course completion than high school students; they largely saw the course as a waste of time and a barrier to academic progress, even though they needed to pass this course to move on to college-level coursework in math. The confluence of these structural and cultural factors may shed light on why the high school students completed the course at a much higher rate than the community college students.

The structures and the expectations at the college level convey an odd combination of both high and low expectations for student performance. The colleges maintained high expectations for student autonomy, self-regulation, and independent work habits, but they held lower expectations in terms of course completion than the high schools. Indeed, the three-module completion requirement in community colleges undermined one of the primary goals of the course design: to enable students to complete all developmental math in a single semester.

The success of the high school students in the course can be understood as the product of good alignment between institutional expectations and actual student behavior. The high schools maintained structures and enacted classroom practices to foster student success given that students are unlikely to have autonomous, self-directed study habits. Community colleges, on the other hand, sustained policy and practice based on the notion that a community college student is autonomous and self-regulated. But according to interviews with stakeholders, many community colleges students, particularly developmental education students, are not very autonomous and self-regulated.

More broadly, I see fully online and hybrid courses implemented at the postsecondary level as a "double whammy" in terms of demands for student self-regulation. The courses require greater learner control and autonomy, and they are also embedded within an institutional context with higher expectations for student autonomy and fewer structures for oversight and management of student work.

It seems reasonable that high schools and colleges would have different expectations for student autonomy. Entrance into college traditionally marks—at least symbolically—the beginning of adulthood, and rising expectations for internal capacity for self-regulation. While it is likely that the high school structures and cultural practices resulted in much stronger outcomes for high school students in this study, it is worth noting that the more active oversight and management of student work and academic behaviors may ultimately do them a disservice if it excuses them from developing internal resources and habits of self-regulation that they will need to be successful in college and careers.

Future research might investigate the extent to which fully online and hybrid courses may facilitate the development of autonomous learning habits and self-regulatory skills in students. This question was beyond the scope of this paper. However, it seems reasonable that by participating in fully online and blended courses, students might be able to develop some of the self-regulatory skills necessary to be successful in these types of courses. Yet as this study suggests, self-regulatory skills may not develop organically in computer-mediated learning environments. It is likely necessary that instructors capitalize on the condition of autonomy imposed on students by these models in order to encourage and scaffold development of stronger academic self-regulation.

A surprising finding from this research is that institutional social organization in terms of the quality of relationships and extent of social networks affects student success in this hybrid course model. This is a counter-intuitive finding as online learning atomizes students, and strips away many of the interactive and social aspects of teaching and learning. However, these data strongly suggest that these types of individualized, self-paced, computer-mediated models are more successful when embedded in social contexts characterized by strong social networks. Relationships, even in online learning environments, create incentives and levers of accountability for students, and encourage students to seek additional help when they need it. Institutions might consider implementing requirements for group work, or dedicate class time to discussion and interaction to foster relationship building in computer-mediated courses.

Readers should bear in mind that course completion in the LSM/SAILS course may not necessarily mean that students have become college ready. A limitation of this study is that we do not know how the students who completed the SAILS or the LSM courses in the 2014-2015 academic year performed in their subsequent, college-level math courses. Research has shown that even when students successfully complete senior-year college-readiness courses in math, they do not necessarily perform well in their first college-level math course (Pheatt, Trimble, & Barnett, 2016). The SAILS course may not adequately prepare all students for success in college-level courses. However, the course does appear to be successful in supporting student acceleration through remedial content.

This research sheds light on the conditions under which students with poor academic preparation can be successful in computer-mediated developmental math courses by revealing key institutional factors that served to support these types of courses at the high school level. The implementation of the SAILS course at the Tennessee high schools was effective in fulfilling the goal to accelerate student progress through remedial content. The implementation of the LSM course at the colleges appears to be less so. Computer-mediated instruction is often touted for its promise to deliver key advantages: efficiency in student learning and lower costs for institutions. This research shows, however, that the conditions under which these reforms bring about the strongest student outcomes may not be labor-saving for institutions. They entail strong and cohesive policies and policy enforcement, as well as sustained commitment to individual student completion and strong relationships among stakeholders.

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