Scaling Online College Readiness Innovations: Preparing Students for College Math

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ABSTRACT

The purpose of this paper is to describe how a state public higher education system is testing and implementing EdReady, an online math readiness system designed to help students avoid the time and cost of remedial mathematics courses. In 2013, the Montana University System (MUS), which includes the state's public 2-year college and university units, implemented a small pilot project for EdReady involving freshmen students who performed poorly on their mathematics placement exam. The state subsequently received a large gift from a private foundation to fund implementation of EdReady statewide. This paper concludes with an introduction to Phase II of the study, which will include nearly 1,400 Montana postsecondary students who used EdReady in Fall 2014. Phase II summary findings and policy recommendations will be completed by August 2015.

INTRODUCTION: CHALLENGES WITH MATHEMATICS REMEDIATION

U.S. secondary and postsecondary educators are working together to address the challenge posed by the number of entering freshmen needing mathematics remediation. Mathematics remediation is embedded in the larger issue of general college remediation. According to Complete College America (CCA; 2012), in 2006, 51.7% of students entering a 2-year college enrolled in a remediation course, and 19.9% of students entering a 4-year college enrolled in a remediation course (p. 6). These statistics are even higher for African Americans, Hispanic Americans, and low-income students. Many students referred to remedial courses do not enroll in remedial courses but instead defer their enrollment into gateway courses, reducing the likelihood they will ever pass those deferred courses or complete a degree (Bailey, 2009). Indeed, "gateway courses can be a roadblock for the vast majority of ALL students—regardless of race, age, or income" (CCA, 2012, p. 8). The entire math remediation process has been called into question, including the use of placement scores to determine whether a student is ready to enter a college math course (Hughes & Scott-Clayton, 2011). Bailey, Jaggars, and Scott-Clayton (2013) argued that many students who are referred to a remedial course may not need it. The authors suggested shortening remedial education sequences, creating multiple measures for placement rather than a single placement cut score, and providing more opportunities for students who place below the minimum score for college math to enroll in the course and receive support concurrently.

The term *remedial education* is often linked with *developmental education*. However,

according to Illich, Hagan, and McCallister (2004), developmental education refers to a broader level of skills necessary for successful college course work, including placement, study skills training, critical thinking, and other support services. Students referred to mathematics remedial courses typically lack skills necessary to succeed in a college mathematics course. The first course in a sequence of either college mathematics or writing is often referred to as a gateway course (Bailey, 2009; Bahr, 2008). Many community college students referred to remedial math courses do not complete them, especially if those courses are two or three levels below the gateway course (Bahr, 2008). Attewell, Lavin, Domina, and Levey (2006) found that few students referred to the lowest remedial math courses (basic arithmetic) ever successfully completed college math. Data from CCA (2012) showed that 62% of community college students complete the remedial math courses they are referred to, and less than 25% of the completers are successful in a college gateway math course within two years.

Students with weak academic skills entering higher education, especially 2-year colleges, face many barriers (Bailey, 2009). Students who are not prepared to enter gateway math courses are typically referred to as semester-long developmental math courses. Depending on one's placement level, one may be required to complete as many as three progressive semesters of developmental math, which means that some students do not enter a college gateway math course until the second half of their second year in college. A significant body of research suggests that the traditional semester developmental math course framework is not successful. Only 30% of students pass all the developmental math courses in which they are enrolled (Attewell, Lavin, Domina, & Levey, 2006). According to CCA (2012), fewer than one in 10 2-year community college students who start their college credential pathway in a remedial course will graduate within three years.

To address the barriers associated with gateway courses, several states (Maryland, Tennessee, Texas) have begun to redesign their gateway courses (CCA, 2012). One promising practice is to end long remedial course sequences and move toward corequisite models instead. Corequisite models provide direct support to students with tutoring, self-paced computer labs, lengthened courses, and alternative pathways to successful course completion. Gateway courses are critical for academic success. According to researchers at the Community College Research Center at Columbia University, "Students who complete at least three required 'gateway' courses in a program of study within a year of enrollment are twice as likely to earn certificates

or degrees" (as cited in CCA, 2012, p. 11).

College general education requirements typically include a mathematics course for all programs. These gateway courses in math can become barriers for many departments. Therefore, unsuccessful remediation in math is a barrier for college success, regardless of a student's interest and field of study.

MONTANA CONTEXT

MUS administrators and faculty are aware of this national and state problem. Recent data showed that throughout the system, 55% of first-time freshmen were enrolled in remedial math at 2-year campuses, with 25% at 4-year campuses. Data also showed that first-time freshmen enrolling in at least one remedial math course in their first academic year tend not to complete a college math course within two years (71% for 2-year colleges and 55% for 4-year colleges). These percentages represent major challenges for each institution and MUS as a whole and suggest the need for new models of developmental education, including how the state approaches remedial math, placement of students into gateway math courses, and corresponding student support.

From the perspective of the Montana Office of the Commissioner of Higher Education, remedial math is not having the desired effect of increasing degree/certificate completion rates in MUS. This issue has given rise to three questions:

- Are we forcing students into remedial classes they may not need?
- Are we providing the support to enable students to succeed in college math courses?
- How are students placed in college math courses?

MUS has engaged in three major efforts to address student success in college mathematics: developmental education reform, a math pathways project, and rethinking semester-long mathematics remedial education courses.

DEVELOPMENTAL EDUCATION REFORM

The first effort was to create a statewide Developmental Education Taskforce in 2012. Its purpose was to make recommendations to the Montana Board of Regents (BOR) about how to improve the state's developmental education programs. The taskforce was co-chaired by one of the authors of this paper. In May 2013, the BOR approved several recommendations from the taskforce:

- Develop improved communication related to college readiness.

- Create a common placement system using multiple measures.
- Leverage best practices to redesign developmental education programs to foster greater student success.
- Create requirements for long-term tracking of students enrolled in developmental courses to gateway courses and on to completion. (MUS, 2013)

In September 2013, the Commissioner of Higher Education for MUS replaced the Developmental Education Taskforce with a permanent Developmental Education Council. Its goal is to accelerate student progress by reducing the time, number of developmental credits, and number of courses in the developmental sequence so students can be successful in a college course (MUS BOR, 2013).

MATH PATHWAYS PROJECT

In the Science and Mathematics Pathways Project, students apply seven essential skills in a real-world context: (a) academic foundations; (b) communications; (c) problem solving and critical thinking; (d) information technology; (e) systems, (f) safety, health, and environment; and (g) leadership and teamwork (MUS, 2014). Montana has been pursuing math pathways with continued support from the Montana Office of the Commissioner of Higher Education. A task force of math faculty from MUS institutions has identified four system-wide goals:

- Increase success rates in college mathematics courses that lead to graduation.
- Improve articulation between mathematics requirements and other academic programs.
- Use data to support system recommendations for placement and student support.
- Develop better communication between secondary schools and colleges. (E. Heckel, personal communication, January 26, 2015)

These math pathways will provide an appropriate series of math courses better aligned with a student's field of study. Informed by institutional and system data, the work of the task force involves working across disciplines to encourage appropriate math requirements in a systematic way. These efforts will result in placing students in the right math courses rather than courses not aligned with their program. Critical to this work will be institutional articulation agreements to ensure transferability of math courses from one MUS institution to another. In addition, program requirements across disciplines are being analyzed as the task force begins

designing corequisite math courses to support student success in the new math pathways.

RETHINKING SEMESTER-LONG MATHEMATICS REMEDIAL EDUCATION COURSES

The third effort is evaluating how MUS approaches semester-long mathematics remedial education courses. The Developmental Education Taskforce identified national best practices in mathematics remedial education, including online mathematics placement testing and remedial programs. One such program was EdReady, which was developed by the National Repository of Online Curriculum (NROC) in conjunction with the Bill & Melinda Gates Foundation. EdReady is an online customized diagnostic tool and a tool for mathematics remediation. "Students can test for college readiness, see study options, and get a personalized study path to fill in their knowledge gaps" (Monterey Institute for Technology and Education, 2015, para. 3). EdReady is also customizable to address specific competencies for any math course, from basic arithmetic to precalculus. Math faculty can customize the competencies in an EdReady assessment to their specific courses. EdReady is not, however, a stand-alone math course.

EdReady Montana consists of 19 units in mathematics with 57 topics. A student who takes the preliminary assessment, which requires approximately an hour, is given a detailed personal plan of study focused only on areas where the student is deficient. The program provides students with a customized study plan. As students progress through the plan, their progress is tracked and charted. Each topic consists of a warm-up activity, short online video presentation, online narration of completed problems, practice problems, and a review session. Once students complete the essential activities related to a topic, they take a test to assess their understanding of the mathematics content. If additional study is required on that topic, students are directed to the appropriate material and they repeat the process described above.

RESEARCH PHASES

The next two sections describe two research phases related to implementation of EdReady in Montana. Phase I is an overview of the results of a Summer 2013 EdReady pilot project that MUS initiated upon an invitation from NROC. Phase II is an overview of planned research for the Fall 2014 expansion of EdReady to five higher education institutions, including two comprehensive 2-year colleges, a regional university, and two flagship universities.

EdReady implementation is occurring across Montana's public higher education system, including the state's 2-year and community colleges, regional universities, and in its two flagship universities. Implementation is tied to an examination of college placement policies.

EdReady provides students with a diagnostic and instructional tool that meets the Complete College Montana strategies as outlined by the Montana Office of the Commissioner of Higher Education (Montana University System Complete College Montana, 2015). The overall goal of Complete College Montana is to increase the percentage of Montana adults with a postsecondary credential, from the state's current rate of 40% to 60% by 2025. One of the five strategies of Complete College Montana is to reform developmental education.

To do this, cost and time for remediation must be decreased. One way to meet these goals is by implementing EdReady Montana, which was supported by a grant from the Dennis & Phyllis Washington Foundation. The Montana Digital Academy (MTDA), housed at the University of Montana (U.M.), is the host organization that oversees EdReady Montana. The backbone of the EdReady Montana system is a software application developed by NROC, a "community-guided, non-profit project focused on new models of digital content development, distribution, and use" (Monterey Institute for Technology and Education, 2015, para. 5). EdReady is designed to help institutions of higher education achieve college readiness goals in mathematics.

Five institutions of higher education are currently participating in the EdReady Montana project. The two flagship institutions, U.M. and Montana State University (MSU) are using EdReady to help students assess their skills and prepare for the math placement test. At Highlands College at M.T. Tech, math instructors are building modules of EdReady into their remedial math and gateway math course instruction. Gallatin College MSU is investigating EdReady as a placement instrument. Montana Western (a regional university) is in the early stages of implementing EdReady and is exploring a variety of applications for the project.

The Montana Office of the Commissioner of Higher Education has partnered with the Educational Leadership Department at U.M. to develop a systematic way of examining the effect of EdReady Montana on participating students. This research consists of two phases. Phase I involved generating data from the EdReady Montana Pilot Project in the summer of 2013.

EDREADY MONTANA RESEARCH PHASE I

In Summer 2013, an EdReady Montana pilot program was conducted at U.M. and overseen by the Montana Digital Academy. Participants were first-time freshmen who were not satisfied with their mathematics placement scores. Initially, 43 students self-selected to participate in the program and

opened an EdReady account. From this group, 37 students followed through and participated in EdReady Montana during Summer 2013. These 37 students comprised the cohort of EdReady students for Phase I of the EdReady Montana study. Phase I was reviewed and approved by U.M.'s Institutional Review Board. Data collected from participants in the 2013 pilot of EdReady Montana will help the Montana Office of the Commissioner of Higher Education measure the impact of EdReady on lowering the number of students placed in developmental education mathematics courses throughout MSU.

Phase I consisted of three parts. In the first part, quantitative data were collected through a web-based questionnaire sent to all U.M. students who were enrolled in either the EdReady pilot program or a developmental mathematics course (090 or 095) in Summer and/or Fall 2013. The surveys solicited general information about participants' perceived confidence for success in the mathematics course as well as with mathematical problems in general. The research question for Part 1 was as follows: Is there a difference in mathematics self-efficacy between students who participated in EdReady Montana and those who went through developmental math?

The questionnaire had two sections. Part A questions were from the Expectancy Component: Self-Efficacy for Learning and Performance of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia & McKeachie, 1991), and Part B questions were from the Mathematics Self-Efficacy Scale-Revised (MSES-R) (Betz & Hackett, 1982). Both instruments have been used widely in mathematics self-efficacy research and both are deemed reliable and valid measures.

The Expectancy Component: Self-Efficacy for Learning and Performance MSLQ assesses expectancy for success and self-efficacy. Expectancy for success refers to performance expectations, and relates specifically to task performance. Self-efficacy is a self-appraisal of one's ability to master a task. Self-efficacy includes judgments about one's ability to accomplish a task as well as one's confidence in one's skills to perform that task. (Pintrich et al., 1991, p.13) The MSES-R was developed in 1982 "to assess the math self-efficacy of college students" (Kranzler & Pajares, 1997, p. 3). The MSES consists of three subscales: (a) solution of math problems, (b) completion of math tasks used in everyday life, and (c) satisfactory performance in college courses that require knowledge of mathematics (Kranzler & Pajares,p. 2). Kranzler and Pajares noted that "Hackett and Betz defined mathematics self-efficacy as 'a

situation or problem-specific assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular [mathematical] task or problem'" (p. 1).

Part 2 of the first research phase involved comparing Fall 2013 grades in a first college math course between students enrolled in 2013 EdReady Montana and students who wentthrough developmental math without experiencing EdReady. The research question for Part 2 was as follows: Is there a difference in first college math course grades for students who went through EdReady Montana compared to students who went through developmental math?

The third and final part of the Phase I study involved analyzing qualitative data from the 2013 EdReady cohort. The research question for Part 3 was as follows: What were the experiences of students who used EdReady Montana in Summer 2013? Interview questions sought attitudes and perceptions of these students. Criteria for analysis were as follows:started EdReady but did not finish, (b) increased by one level on ALEKS, or (c) increased by two levels on ALEKS. The ALEKS (Assessment and Learning in Knowledge Spaces) is a web-based, artificially intelligent assessment and learning system used by U.M. to determine the appropriate entry-level math course for a student.

PRELIMINARY FINDINGS FOR PHASE I.

Perhaps because of the pilot study's small sample size, inferential statistical analysis did not reveal any statistically significant differences between the mathematics self-efficacy of EdReady students and those who went through remedial math. The mean response was higher for EdReady students on 19 questions compared to 20 questions for non-EdReady students. When responses to questions regarding basic math are compared to those regarding higher-level math, differences begin to emerge. Regarding questions that addressed basic math skills, the mean responses for EdReady students were higher on 13 questions compared to 2 questions for non-EdReady students. The reverse trend is true for questions regarding higher-level math skills. The mean responses were higher on two questions for EdReady students and 15 questions for non-EdReady students. In conclusion, while trends are emerging, there is no statistically significant difference in mathematics self-efficacy between U.M. students who used EdReady in their developmental mathematics courses and those who did not during Summer or Fall 2013. It is speculated that these results reflect the small sample size. This issue warrants future investigation, which is planned for Phase II.

Although comparison of the two groups involved in Phase I did not yield statistically

significant differences, some results illustrate trends that warrant continuing study. For example, of the EdReady students completing the pilot program, 70% increased by 1 ALEKS point, 27% increased by 2 ALEKS point, and 3% increased by 3 ALEKS points (scale of 1-5). In total, 86% of pilot students increased their ALEKS score by at least 1 point and thereby qualified to enroll in a higher math course at U.M.

Grades for a first college math course were compared between students who went through EdReady and those who went through developmental math. A college math course is defined as one at the 100 level or higher. Courses taken by students in this sample were Math 105, 115, 121, 135, 151, 162, and 171. The determination of which course students take depends on their major. To quantify the data, letter grades were assigned grade points according to the following scale: A = 4.0; A- = 3.67; B+ = 3.33; B = 3.0; B- = 2.67; C+ = 2.33; C = 2; C- = 1.67; D+ = 1.33; D = 1; D- = .67; F = 1.

For non-EdReady students who spent a semester (or more) in developmental math (Math 090 or 095), the mean grade-point was 2.34 (about a C+). The EdReady students had a mean grade point of 3.03 (about a B). It should be noted that there was a large difference in size between the two groups. In the EdReady cohort, 27 (72.9%) students took a college math course in Fall 2013. In contrast, 221 (31.2%) developmental math students moved into a college math course in that semester.

Table 1 shows the mean grade point for EdReady students and developmental math students in each college math course.

Table 1 EdReady vs. Developmental Math Students' Grade Point Averages

		Course						
		105	**115**	**121**	**135**	**151**	**162**	**171**
EdReady	*M*	3.25	2.78	2.87	3.00	3.78	2.66	3.00
	n	4	3	10	1	3	2	2
Develop. math	*M*	2.28	2.09	2.58	2.11	2.67		
	n	39	69	84	22	7		

As Table 1 illustrates, for every course studied, EdReady students received higher grades than did those students who ascended from developmental math. Again, it is important to note the difference in the number of students in each group. In Phase II of this study, the population

will be over 1,000 EdReady students.

EDREADY MONTANA RESEARCH PHASE II

Phase II of the EdReady Montana study will consist of three separate but integrated parts that expand on Phase I. This will be a mixed-methods, cross-case study employing embedded analysis (Yin, 2003) where a specific aspect of each case will be examined. In each case, pertinent information regarding EdReady will be sought. The case's context will be described (Yin, 2003), followed by an analysis of themes (Creswell, 2013). The final narrative will report the meaning of the case based on data analysis of observations, interviews, document analysis, surveys, and student grades.

The three parts of Phase II are (a) self-efficacy survey administered to all students in three institutions who have taken one year of college-level mathematics, (b) comparison of grades in first college mathematics class, and (c) qualitative analysis of participants' learning experience. The sample in Phase I consisted of the 37 EdReady students in the pilot program.

The population of EdReady students in Phase II will be greatly expanded:

- University of Montana – 760 EdReady students
- Highlands College at Montana Tech – 384 EdReady students
- Gallatin College MSU – 170 EdReady students
- University of Montana Western – Number of students to be determined

U.M. is a research high-activity flagship university for Montana. Highlands College at M.T. Tech and Gallatin College MSU are both 2-year colleges. Each case represents a unique application and implementation of EdReady. Although each case will be studied individually, relationships among the cases and implementation strategies will also be considered.

Phase II, Part 1 – Self-efficacy.

Bandura (1977) stated that students experiencing goal-oriented academic mastery (which EdReady seeks to provide) would develop greater self-efficacy. As used here, the term *self- efficacy* is defined as the belief in one's ability to accomplish a task. Self-efficacy is the underlying construct for the first part of the Phase II study. In addition to gathering basic demographic data and general attitudinal information about developmental course and EdReady experiences, the researchers will employ a subcomponent of the MSLQ to measure students' self-efficacy for learning and performance. In particular, the Self-Efficacy for Learning and Performance component is a latent variable whose

value is inferred through eight questions. The self-efficacy survey will be administered to all students in cohorts 2013 and 2014.

> Descriptive statistics, a $\chi 2$ test for each group by response for attitudinal items, and a *t* test for independent means to compare the latent variable self-efficacy will be employed to test the differences between EdReady students and students who enrolled in either of the two developmental mathematics courses (M090 or M095) during the same period. Data analysis will be conducted using Qualtrics software.
>
> The Self-Efficacy survey will be administered to all additional EdReady participants.

Results will be reported and compared to data from the Phase I study. Comparisons will also be made among cases.

Phase II, Part 2 – College math success.

Grades in the first college math course will be compared between those who went through EdReady Montana and those who went through developmental math or directly into college math. The independent variables are the same as in Phase I, with the addition of students who went directly to college-level math without developmental math or EdReady. The dependent variable is the final grade in students' first college math course.

For each case (U.M., University of Montana-Western, Gallatin College MSU, and Highlands College at M.T. Tech), the final grades for all students taking their first college math class will be compiled. College math courses are defined as 100 level or above. These data will be divided into three groups: those who went (a) through EdReady, (b) through developmental math, or (c) directly to college-level math. A multiple regression will be applied to these data to explore relationships among variables.

Phase II, Part 3 – Qualitative inquiry.

Researchers will conduct interviews with purposefully selected participants to explore EdReady student experiences in each case. Participants from four institutions (U.M., University of Montana-Western, Gallatin College MSU, and Highlands College at M.T. Tech) will be identified in each of the following four subgroups: (a) started EdReady but did not finish; (b) took EdReady, qualified for college math, but waited to take their first college math course; (c) took EdReady and went directly into a college math course, and (d) took EdReady and chose to go into a developmental math course. In addition, instructors and administrators who are directly connected to the project in each of these institutions will be interviewed to better understand the implementation, potential, and possible future directions of EdReady Montana.

IMPLICATIONS

Implications for Research

The Phase I research design was based on findings in the literature regarding the association between self-efficacy and academic outcomes. Self-efficacious students have heightened confidence and are more likely to persist through difficult material (Komarraju & Nadler, 2013; Schunk, 1991). Even more encouraging are Gore's (2005) findings suggesting that academic self-efficacy beliefs predict future college outcomes. Further research into EdReady should continue to explore the relationship between the program and students' sense of self- efficacy in math, in particular, to examine the relationship between participation in EdReady and future college success at both the course and degree levels. In addition to the initial lines of inquiry in Phase I, subsequent studies should collect quantitative and qualitative data from students experiencing EdReady through a variety of formats: EdReady as a stand-alone program supporting student improvement with math placement, as a supplement to either remedial math or college gateway math course, or fully integrated with a college-level math course.

Finally, there is potential for replicability across institutions and university systems from each phase of research conducted through MUS. Future cases might include City College at MSU Billings, Great Falls College MSU, Helena College U.M., Missoula College U.M., Bitterroot College U.M., Flathead Valley Community College, Miles Community College, Dawson Community College and the Montana Tribal Colleges. As EdReady expands its impact in Montana, MUS will continue to evaluate its progress.

Implications for Institutions

As the benefits of EdReady Montana become more evident, EdReady has the potential to assist students as a corequisite component of a required course rather than its current role as a remediation experience. A corequisite can pertain to college or technical math courses. Other institutions might find EdReady beneficial as a tool for academic support, either as part of math instruction or a developmental mathematics course. EdReady also has potential as bridge support for entering freshmen who may lack necessary math skills, as well as secondary students struggling with math. Finally, there is strong potential for EdReady's use as a math placement tool for students entering postsecondary education.

Implications for Policy

Data indicate that the current model of delivering remedial courses in higher education is not working (Bailey, 2009; CCA, 2012). As university systems consider redesigning math pathways, those decisions must be informed by research. Although Phase II of the EdReady Montana study is not yet complete, it is anticipated that results will inform MUS policy decisions at the institution and system levels. These decisions will call for new and revised policies regarding (a) placement of students in college gateway math courses, (b) the role of EdReady in providing academic support as either a prerequisite or corequisite, and (c) recommendations for redesigning remedial math courses including the use of EdReady to provide academic support for students otherwise unprepared for a college gateway math course. There are also national and international implications for policy as other states and nations address similar issues related to poor success rates for students enrolled in traditional math remediation courses and overall student completion rates of college math courses required for a postsecondary credentialing.

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