Tracking Developmental Students into Their First College Level Mathematics Course

By Pansy Waycaster, Ph.D.

Background

Based on studies done in 1989 and 1992 by the National Center for Developmental education, "only 14% of the developmental programs at two-year colleges and 25% at four-year institutions engage in ongoing, systematic evaluation" (Boylan, Bonham, & Bliss, 1994). In spite of these low statistics, several researchers have found a positive correlation between program evaluation and retention/success in developmental mathematics programs (Boylan, et al., 1997; Casagga &Silverman, 1996; Congas & Schoeps, 1977; and Maxwell, 1985). Even though there is a need for strong program evaluation to assess effectiveness and to make recommendations for program improvement to better student outcomes, a review of the literature reveals only a few studies or research efforts linking program evaluation to program effectiveness.

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First, Kristine Young (2002) reports three related pieces of research which have followed developmental students into their college level mathematics courses. McCabe and Day (1998) found that students who complete remedial programs are as successful in college-level work as those who begin academically prepared. Second, Schoenecher, Bollman, and Evans (1996) reported similar findings for twenty-one public community colleges in Minnesota. Schoenecher et al. show that the successfully remediated students performed as well or better than students who had started college academically prepared. Finally, Klicha (1998) argues that data collected by the BCCC (Bucks County Community College) in Newton, Pennsylvania documents that program completers do as well as non-developmental students in college level work. As noted by McCabe (2000), only one percent of all monies spent in higher education in the United States are spent on remedial

education. In spotlighting these three areas of research, Young has shown that remedial education programs can be economical and effective. She offers a convincing argument that for a reasonable cost, these studies show that students who have completed sequences in developmental programs perform as well or better than college ready students in college level courses.

Aside from the research efforts reported by Young, there are three dissertation efforts which assess developmental mathematics programs by tracking students into future college level mathematics courses. First, Terry Lynn Hutson (1999) examined the effectiveness of the developmental mathematics courses in preparing students for the next course in the mathematics sequence. The study found that students performed equally well in College Algebra whether they advanced from Intermediate Algebra or placed directly into College Algebra.

Second, Richard Andrew Burt (2006) studied the extent of difference between the success rates of students severely unprepared for college entry coursework and the success rates of two groups of their colleagues. The study considered five different areas, one of which was success in first year mathematics courses. Burt (p.47) compared data from the severely underprepared group (SU) to corresponding data on a group of students in higher levels of developmental math (DEV) and to corresponding data on a group of students who placed directly into traditional freshman math (REG). One of Burt's specific research questions (p.49) was: *What is the extent of difference in first semester math pass rates among students who are severely underprepared, students who place into higher level developmental coursework, and students who place directly into a traditional math course?* The overall result (Burt, p.57) was that SU students performed as well as, or better, in the individual courses they took than their higher-placing counterparts.

Third, Allyson Faye Fleming (2000) analyzed the outcomes of students who were placed in developmental studies courses at Tennessee State University. Her goal was to determine to what extent placement of students into the Developmental Studies courses might have impacted their level of academic achievement and retention. One of her findings (p. 64) was that students who were placed in developmental studies courses because of academic deficiencies had, on average, an overall university GPA of 2.25. This average GPA is higher than the required GPA of 2.00 needed for graduation. She argued that this result suggested that these students, who would not have been able to attend university had it not been for developmental studies, were able to master college after being exposed to the developmental studies program, and thus developmental studies should continue.

Current Research

A recent SACS review at our institution prompted an assessment of our developmental mathematics program. We needed to examine the effectiveness of our developmental mathematics courses in preparing students for their first college level mathematics course. Rather than just examine success rates in developmental mathematics courses, we chose to compare the success rates of developmental mathematics students to the success rates of non-developmental students in their first college level mathematics courses. Specifically, we tracked developmental students from their last prerequisite developmental mathematics course into their first college level mathematics course. The developmental cohort consisted of only those students who had *successfully* completed their developmental coursework *before* enrolling in their first college level mathematics course. Furthermore, students in the developmental cohort must have enrolled in their first college level mathematics course within one year of the time they completed their last required developmental mathematics course. This last aspect of the study ensured that content learned in the developmental mathematics course would still be current enough to assist the students in their college level mathematics courses. The chart below details the appropriate paths for students to follow from their last required developmental mathematics course before taking their college level mathematics course. These paths also serve as a map for comparing the success rates for developmental and non developmental students in these college level courses.

Exit Developmental Math Course	College Level Math Course
MTH 02 (Arithmetic) MTH 03 (Algebra I)	MTH 141 (Business Mathematics I) MTH 126 (Mathematics for Allied Health) MTH 146 (Introduction to Elementary Statistics)
MTH 04 (Algebra II)	MTH 151 (Mathematics for the Liberal Arts I) MTH 152 (Mathematics for the Liberal Arts II) MTH 158 (College Algebra) MTH 163 (Precalculus I)
MTH 06 (Geometry)	MTH 151 (Mathematics for the Liberal Arts I) MTH 163 (Precalculus I)

Thus the purpose of this project was to track developmental mathematics students who have successfully completed their last required developmental mathematics course into their *first* college level mathematics class and compare their success rates in this college level course with the success

rate of non-developmental students in the same course. For the purposes of this study, success is defined as a grade of C or better in these college level mathematics courses.

The following charts provide the numbers of developmental and non-developmental students, as well as their success rates in each of seven first college level mathematics courses at our college during the 2006-2008 academic years. The final chart combines all of these courses into one table and provides the same data. The null hypothesis in this study is that there is no difference in success rates for the developmental and non-developmental mathematics students.

Math 141 - Business Mathematics I

	Success	Failure	% Success
Dev	12	7	12/19 = 63%
Non-Dev	108	64	108/72 = 63%

The developmental students enrolled in Business Math for their first college level math course had the same success rate of 63% as the non-developmental students.

Math 146 - Introduction to Elementary Statistics

	Success	Failure	% Success
Dev	18	5	18/23 = 78%
Non-Dev	57	17	57/74 = 77%

Developmental students taking Introduction to Elementary Statistics for their first college level math course achieved a 78% success rate, which is comparable to the 77% success rate of the non-developmental students in the same course.

Math 126 - Mathematics for Allied Health

	Success	Failure	% Success
Dev	17	4	17/21 = 81%
Non-Dev	156	33	98/189 = 83%

The developmental students taking Mathematics for Allied Health for their first college level math course again succeeded comparably with the non-developmental students in the same course, with 81% and 83% success respectively.

Math 151 - Mathematics for the Liberal Arts I

	Success	Failure	% Success
Dev	20	2	20/22 = 91%
Non-Dev	58	15	58/74 = 79%

Developmental students taking Mathematics for The Liberal Arts I for their first college level math course outperformed their non-developmental counterparts with a 90% success rate as compared to a 79% success rate for the non-developmental students.

Math 152 -Mathematics for the Liberal Arts II

	Success	Failure	% Success
Dev	3	1	3/4 = 75%
Non-Dev	13	3	13/16 = 81%

We should point out that we are considering both Math 151 and Math 152 in this study because students may begin this sequence in either order or simultaneously. We should further point out that if a student were enrolled in both of these courses during the 2006-2007 academic year; we included only that course which the student enrolled in first. Developmental students taking Mathematics for The Liberal Arts II for their first college level math course performed comparably, with a 75% success rate, to the non-developmental students in the same course, who had an 81% success rate.

Math 158 - College Algebra

	Success	Failure	% Success
Dev	6	2	6/8 = 75%
Non-Dev	28	22	28/50 = 56%

Developmental students taking College Algebra for their first college level math course outperformed, with a 75% success rate, the non-developmental students in the same course, who achieved a 56% success rate. One possible reason for the developmental group having a higher success rate in this course may be that they had just successfully completed Math 04 – Intermediate Algebra – which provided them with a basic coverage of the content covered in College Algebra. MTH 158 serves as a bridging course for those students who pass MTH 04 but are still not quite ready for Precalculus.

Math 163 - Precalculus I

	Success	Failure	% Success
Dev	31	10	31/41 = 76%
Non-Dev	269	71	269/340 = 79%

The developmental student taking Precalculus I for their first college level math course again performed comparably, with an 76% success rate, to the non-developmental students in the same course, who had a 79% success rate.

Some students are required to take MTH 06 after taking MTH 04, before taking their first college level math course, so these students were also tracked into their first college level math course for the second year of the study. Data was not obtained for these students during the first of year, 2006-2007.

Math 06 to Math 151 - Mathematics for the Liberal Arts I

	Success	Failure	% Success
Dev	1	0	1/1 = 100%
Non-Dev	33	5	33/38 = 87%

The developmental student taking Mathematics for The Liberal Arts I for their first college level math after MTH 06 course outperformed the non-developmental counterparts with a 100% success rate as compared to a 87% success rate.

Math 06 to Math 163 - Precalculus I

	Success	Failure	% Success
Dev	6	3	6/9 = 67%
Non-Dev	160	37	160/197 = 81%

The developmental students taking Precalculus I for their first college level math course after MTH 06 did not perform as well, with a 67% success rate, as compared to an 81% success rate for the non-developmental students in the same course.

All Courses Combined

	Success	Failure	% Success
Dev	114	34	114/148 = 77%
Non-Dev	682	222	682/905 = 75%

$p = 0.68 \geq .05$

Finally we merge all of the students from the separate courses into one group and find that the success rates are indeed most comparable, developmental with 77% and non-developmental with 75%. Since the 2-proportion z-test is valid for this data with all the courses combined, the computed p value can be used to test the null hypothesis. The p value of 0.68 from the 2-proportion z-test was greater than .05, so we do not reject the null hypothesis. In other words, there is no difference in success rates between the developmental and

non-developmental students in their first college level mathematics courses. In conclusion we argue that once students weak in mathematics background complete their developmental coursework in mathematics, they are indeed ready to enroll in college level mathematics courses.

Extended Tracking

When presenting this data to local math groups, questions rose as to how these success rates would compare for online versus face-to-face classes. In response to these comments and at the request of my Dean, this tracking was carried out for online and face-to-face classes for the eight academic years 2001-2008. First, Table 1 and Table 2 present the success rates and percentages for four developmental mathematics courses — MTH 02, MTH 03, MTH 04, and MTH 06—for the two academic calendar years (six semesters) 2006-2008. (It should be noted that a grade of R is counted as a failure.) Table 1 presents success rates for online and face-to-face classes **combined**. Table 2 presents success data **separately** for online and face-to-face classes.

Table 1:
Overall Success Rates in Developmental Mathematics Courses 2006-2008

Course	Success	Failure	% Success
MTH 02	140	106	140/246 = 57%
MTH 03	281	211	281/492 = 57%
MTH 04	112	122	112/234 = 48%
MTH 06	34	22	34/56 = 61%

Table 2:
Success Rates in Developmental Math Courses 2006-2008:
Online versus Face-to-Face Classes

Course	Online	Face-to-Face
MTH 02	51/83=61%	89/163 =5 5%
MTH 03	46/112=41%	235/375 = 63%
MTH 04	_____	112/233 = 48%
MTH 06	_____	34/56 = 61%

Since MTH 04 (Intermediate Algebra) and MTH 06 (Geometry) were not taught online during this two-year study, no data was available for comparison with face-to-face classes. It should be noted that the success rates during this two-year period were comparable for online and face-to-face MTH 02 classes during this two year period, but the success rate was 22 percentage points lower (41% versus 63%) for online MTH 03 classes.

After comparing success rates for online and face-to-face students for the 2006-2008 period, online and face-to-face students were tracked, separately, from MTH 03 into their next math course for 2001-2008. Table 3 presents the success rates for online and face-to-face mathematics students. The MTH 03 students did not proceed to take the subsequent math course, but stopped with completion of MTH 03. However, 8 of the 88 online and 17 of the 442 face-to-face students took the MTH 03 course in 2008, which means they may have take the subsequent math course during 2009. It should also be noted that the other category includes those students who continued with a college level math course other than MTH 04, after MTH 03. These courses were: MTH 151, MTH 152, MTH 163, MTH 164, MTH 141, MTH 146, MTH 240, MTH 241 MTH 126, and MTH 158. Interestingly enough, 10% of these students (online and face-to-face) who had just completed MTH 03 were able to succeed in these other college level math courses.

Table 3: Success Rates for MTH 03 and MTH 04 Online and Face-to-Face Students 2001-2008

Course	Online	Face-to-Face	*p*-value
MTH 03	88/331 = 27%	442/1346 = 33%	$p=.03 \leq .05$
MTH 04	40/331 = 12%	229/1346 = 17%	$p=.03 \leq .05$
Other	32/331 = 10%	140/1346 = 10%	

The 2-proportion z-test is valid for this data which means that it yields a good normal approximation to the binomial data (success or failure) in this study. Comparing the online and face-to-face success rates for MTH 03, the computed *p* value of 0.03 was less than 0.05 which means we can **reject** the null hypothesis that there is no difference in success rates between the online and face-to-face students taking MTH 03 over the academic years 2001-2008. Comparing the online and face-to-face success rates for MTH 04, the computed *p* value of 0.03 was less than 0.05 which means we can **reject** the null hypothesis that there is no difference in success rates between the online and face-to-face students taking MTH 04 over this same period. In other words, face-to-face students are performing significantly better in MTH 03 and MTH 04 than online students.

Discussion

Tables 1and 2 data from 2006-2008 reveal that overall **57%** (61% online and 55% face-to-face)of the MTH 02-Arithmetic; **57%** (41% online and 63% face-to-face) of the MTH 03-Algebra I students, and **48%** (all face-to-face) of the MTH 04-Algebra II students do indeed succeed in these developmental math courses. Furthermore, the tracking data for this same period show that 77% of these students go on to succeed in their first college level math courses, as

compared to 75% of the non-developmental math students in the same college level courses. So for this two-year period, those students who did complete their recommended developmental math courses and, within a year, proceed to take their first college level math courses do succeed at a comparable rate to that of non-developmental students. If we stopped our tracking here, then this data would provide a positive scenario for our developmental math students. But the extended tracking for MTH 03, broken down by method of teaching (online versus face-to-face), paints a somewhat different picture.

Table 3 presents the 2001-2008 overall success percentages of **32%** (27% online and 33% face-to-face) for MTH 03 and **16%** (12% online and 17% face-to-face) for MTH 04. These percentages are quite lower than the 2006-2008 success rates for the same courses, reported above. But how can these success rates be so different? One explanation may be that the tracking data includes the students who drop out of developmental and/or college altogether during this eight year period, counting them as failures, and the two-year period data does not include these students. Thus the two-year period will only report the efforts of first time developmental students and those students repeating the course. So the tracking data will have much higher failure rates, but will also present a more complete picture over the long term.

The findings in this extended tracking suggest that the problem with our developmental mathematics program is twofold. First, our student success rates over time in developmental courses are not as good as we once believed from our yearly tracking practices. Thus, changes need to be made in the program so that more students can successfully complete their developmental coursework and go on to enroll in the college level math courses required for their area of study. The second problem is that students in online developmental math courses (MTH 03 and MTH 04) succeed at a significantly lower rate than students in face-to-face classes. This comes as no surprise, as students in online classes do not have the regular classroom interactions with a teacher and other students, and receive less structure and guidance in the routine of doing homework and learning mathematics. But it behooves us as developmental educators to incorporate the structural items present in a face-to-face classroom into our online classes. Such an effort could increase the success rates of our online developmental math students.

Recommendations

The Community College Research Center Report (CCRC, 2009), the presentation of the CCRC study (Jenkins, 2009) to the VCCS Advisory Council of Presidents, a draft from the VCCS Developmental Task Force responding to the CCRC report (2009), and Smittle's article (2001), *Essential Attributes for Developmental Education Teachers*, along with the current

analysis of data regarding developmental mathematics have prompted the following responses.

First, page 11 of the draft from the Task Force (2009) lists one of their three goals—to reduce the time to complete the developmental math requirements for students. This is a commendable goal and our college, beginning summer, 2010, is offering a MTH 05 course for students who have borderline COMPASS scores for being placed into MTH 04. So these students will be able to complete MTH 03 and MTH 04 in one semester instead of two.

Pages 4 and 35 of the CCRC report (2009) recommend finding alternative pathways for students starting at the lowest level of the developmental mathematics sequence—MTH 02, Arithmetic. Our college is working on another combined course for MTH 02 and MTH 03 for students who have borderline COMPASS scores for being placed into MTH 03. In a similar fashion these students will be able to complete MTH 02 and MTH 03 in one semester, instead of two. A second alternative for those students needing the entire MTH 02 course is to advise them to take the course in the summer prior to the beginning of their fall semester. Completing MTH 02 in the summer would then make it possible to complete the remainder of their developmental coursework in one academic year.

A second recommendation of the CCRC report (p. 21, Jenkins, 2009) is an "investigation of course structures and instructional techniques that improve effectiveness of online courses among underprepared students." As mentioned in the discussion above, this recommendation is vital for developmental students. Since developmental students are free to self-select into online courses, it is imperative that we structure online developmental math classes in such a way that the students receive as much attention and assistance as the students in face-to-face classes. The following guidelines will help to bring about this change in structure.

- **Use the best textbook and/or format available for online courses,** i.e. one that contains high quality online lectures with detailed assistance when working examples in the reading assignments as well as when doing homework. Students should be able to get help on homework when they need it and good online math courses have such help available 24/7. MyMathLab is one such online source provided by Pearson publishing company. One online teacher and all face-to-face teachers will have this source available to all of their students beginning fall, 2010 at our college.

- **Provide a schedule of activities with deadlines.** This agenda will guide the student through the material and enable him or her to complete the course by the end of the semester. Instructors should check the online activity of the students regularly to ensure students are spending enough time engaged with the course.

- **Include regular quizzes.** A multiple choice format is most practical for quizzes, as students can get results quickly, proceed to correct mistakes and continue with their lessons.

- **Do not use multiple choice tests**, but use open-ended tests, which are graded diagnostically by the instructor. This technique will help the student find and correct mistakes on the test and better understand the material for future work.

Smittle (p. 3) says that her "studies of personality types of developmental students indicate that they need structure." These guidelines will provide structure for the online developmental student.

Third, tracking developmental students over time and into subsequent college level math courses is recommended by the CCRC report (p. 5 & p. 40) and Smittle (p. 3) points out that "One of the measures of a successful developmental education program is the success of students in subsequent courses." The Task Force (p. 10) reminds us that "Developmental education courses were designed to serve as a means to provide the academic preparation students need in order to be successful in their subsequent college-level courses." Thus, tracking developmental students is essential to determine if our developmental math programs are successful.

A fourth and related recommendation was sparked by a keynote address to the Virginia Mathematical Association of Two-Year Colleges (VMATYC) April, 2008, in Charlottesville, Virginia. Dr. Susan Wood, Vice Chancellor for Academic Services and Research for the VCCS (Virginia Community College System) and a past President of AMATYC (American Mathematical Association of Two-Year Colleges), suggested that perhaps we might mark student success in community colleges in different ways. For example, we could look at the percentage of students who: complete the General Education sequence; enroll in and successfully complete our gatekeeper math courses – Math 163 and Math 151; complete their developmental course requirements; or complete 12 or 24 credit hours. These are all measures of success for the community college student. And consistent with the above list of suggested milestones is the one addressed in this paper, i.e. students who successfully complete their developmental mathematics course requirements and their first college level mathematics courses. Thus, colleges should not only track

developmental students into subsequent math courses, but also monitor the completion of developmental courses, general education courses, and gatekeeper courses.

Last, but certainly not least, ongoing professional development is crucial to the success of a developmental math program. As Smittle (p. 1) points out "Teachers are the key components to student success and retention…and the argument that anybody can teach developmental students is absolutely false." She goes on to say that (p. 4) "many teachers teach developmental students for reasons not in the best interest of students — the class fits their desired schedule, they think the developmental course will require less preparation than higher level content courses, they may be banned from teaching other content courses, they may be teaching out-of-field and the college allows them to teach developmental courses." She concludes (p. 6) that since most colleges do not have a staff that is professionally trained in the field of developmental education, comprehensive, on-going training is imperative for successful programs, and this is especially true since colleges are using many part-time teachers. Thus, including adjunct instructors in professional development activities is essential to ensure all faculty members are well-prepared to work with developmental math students.

Dr. Pansy Waycaster is currently Professor of Mathematics in the Science and Engineering Technologies Division at Virginia Highlands. She received a B.A. from Berea College, M.A. from Eastern Kentucky University, and a Ph.D. from Indiana University, Bloomington. She has taught primarily developmental mathematics in two-year and/or four-year colleges since 1975, the last twenty of which have been with the VCCS. She currently is serving on the PTT (Placement Test Team) for the Developmental Mathematics Redesign project. She has a son, Cory, a daughter, Nicole, and a son-in-law, Allen.

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