Effective Evaluation of Developmental Education: A Mathematics Example

By Sara W. Wheeler and Nathaniel Bray

Abstract: ***This study examined whether a correlation was present between demographic variables and academic success at a two-year institution in Alabama. Developmental status, gender, and race were compared with pass/fail status in the first college-level math class and graduation status. Results indicated that the developmental math classes were effective because the developmental students performed as well as the non-developmental group in each of the variables on academic success tested. This study concluded that developmental status, gender, and race were related to student success outcomes of college-level math pass/fail status and graduation status.***

Given the large numbers of students served, the cost per student may be much smaller than expected.

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For centuries, higher education has served citizens by offering an opportunity for advancement – whether in a career, in the pursuit of learning for the sake of gaining knowledge, or in social status. Regardless of the eagerness of aswe potential learner, there is a possibility that the student can reach the college level underprepared for a variety of reasons, which leads to the need for developmental work. In particular, the number of students who reach public two-year institutions in the nation and enroll in developmental classes continues to hover around 40% (Altbach, Gumport, & Berdahl, 2011; NCES [National Center for Education Statistics] , 2003, 2012b). Moreover, in the 2011–2012 school year, over 75% of public four-year and almost 100% of public two-year institutions reported offering remedial services (NCES, 2012a). Federal and state policymakers, students, administrators, teachers, and taxpayers are vested in higher education and are now seeing the task of improving developmental programs as a major priority (Bahr, 2010; Bailey, Jaggars, & Scott-Clayton, 2013; Cullinane & Treisman, 2010). It is important for program coordinators and administrators to not only understand the need for evaluating a program, but to also look at the right information. Due to the cost and lack of adequate data surrounding this area of postsecondary learning, stakeholders are called to ensure proper attention is given to evaluating the courses in a useful and efficient manner.

It has been suggested that developmental education is perhaps the most utilized and expensive program geared toward preparing students who are not ready for college-level work (Scott-Clayton & Rodriguez, 2012). It should be noted, though, that given the large numbers of students served, the cost per student may be much smaller than expected particularly given the benefit of helping students succeed when they might not otherwise. The cost factors associated with developmental education include an increased cost due to hiring tutors with adequate credentials, faculty training, and implementation of student services and/or programs for success and retention (Gallard, Albritton, & Morgan, 2010). Higher education leaders are surrounded by a decline in public opinion and cuts in public funding (Briggs, Stark, & Rowland-Poplawski, 2003). The problems facing higher education are heightened because there are so many financial reductions despite an increase in demand and accountability (Lueddeke, 1999). Offering developmental courses costs the nation anywhere between $1.13 billion and $2 billion annually (Denley, 2013; Pretlow & Wathington, 2012). Since public institutions are encouraged to educate all who can benefit from higher education (Bonham & Boylan, 2011; Ignash, 1997), administrators and practitioners have the task of finding ways to improve its effectiveness in order to better serve students and be accountable to taxpayers.

Along with the cost of developmental education are the problems associated with evaluation. Even though almost half of first-time college students require developmental courses each year (Altbach et al., 2011; NCES 2003, 2012b), research on the issue of the effectiveness of these courses is scarce (Breneman & Haarlow, 1998; Calcagno & Long, 2009). Despite the large expenses involved and the continuous debate about whether and/or where to offer developmental courses, there is a large gap in the research concerning the effectiveness of these programs (Calcagno & Long). Oddly enough, most colleges in the nation do not even evaluate their developmental programs (Bahr, 2008; Grubb, 2001). Those that do perform evaluations fail to conduct them in a systematic manner that continuously occurs each academic year (Boylan, Bliss, & Bonham, 1997; Collins, 2010).

Data on the effectiveness of remedial programs has not been fluid, has not been adequately funded, and has not been comprehensive or complete (Merisotis & Phipps, 2000).

Due to concerns over cost and effective evaluation, it is clear that standards are needed to ensure that developmental education is evaluated in a meaningful way. Focusing on mathematics in particular, there are many opinions on effective evaluation. Researchers see value in collecting data on passing rate in the first college-level math class (Bailey, Jeong, & Cho, 2010; Boggs, 1997; Brothen & Wambach, 2012; Collins, 2010; Merisotis & Phipps, 2000; Nichols & Nichols, 2005) and college graduation rates (Boggs, 1997; Collins, 2010; Merisotis & Phipps, 2000). Studying these variables offers a template for evaluating a developmental program.

Literature Review

Basic skills courses arguably date back to the early American colonial colleges of the 1600s (Breneman & Haarlow, 1998; Brubacher & Rudy, 2008; Keimig, 1983; Merisotis & Phipps, 2000). Developmental classes have been and remain important since they are building blocks that can lead students to programs that provide them with the skills necessary for a job or advancement. The United States economy depends on a population with at least minimal reading, writing, and math ability (Bahr, 2010), which is also an important component to maintain global competitiveness (Talbert, 2012). These programs also provide underprepared students with not only subject-specific skills, but skills necessary to succeed in college, earn a college credential, and become gainfully employed in the labor market (Bettinger & Long, 2005; Bonham & Boylan, 2011). Furthermore, the programs offer a wide variety of services to students who wish to attend college but do not have the success skills needed. These include study skills, time management skills, and other soft skills that accompany the subject-specific training (Bailey et al., 2013; Le, Rogers, & Santos, 2011). Since 75% of students who begin developmental math courses never reach the college-level course (Bahr, 2007), there is much work to do in ensuring success for everyone who hopes to pursue this level of education.

Many oppose developmental education at the college level and push for these programs to be eliminated (Adelman, 1996; Bahr, 2008, 2010; Blanchette, 1997; Hebel, 1999; McCabe & Day, 1998; Phipps, 1999). Some claim that the courses act as a barrier as opposed to a benefit (Bonham & Boylan, 2011). Other reasons given for eliminating developmental education are due to the fact that the courses cost students and institutions too much time and money (Adelman1996; Bahr, 2008, 2010; Blanchette, 1997; Calcagno & Long, 2009; Hebel, 1999; Howell, 2011; Phipps, 1999; McCabe & Day, 1998; Walker & Plata, 2000). Turning away from the business side and looking more at the human element involved, the classes may serve a role of belittlement to faculty, alumni, and students (Bettinger & Long, 2009; Walker & Plata, 2000). Finally, many researchers claim there is no proof the courses even prepare students for college work (Bahr, 2013; Crisp & Nora, 2010; Cullinane & Treisman, 2010; Kolajo, 2010).

Moving to the other end of the spectrum, many scholars firmly believe that developmental education serves an important role in higher education. In terms of social equity, developmental programs are important for access issues since statistics show that many students of color, students who are first-time degree seekers, students from less wealthy families, and English as a second language (ESL) students need skills training (Altbach et al., 2011; Crisp & Nora, 2010; Howell, 2011; Lavin, Alba, & Silberstein, 1981; NCES, 2012a). Some advocate for developmental education because the workforce development and knowledge gained builds communities (Altbach et al., 2011; Bahr, 2010) as well as the nation (Bahr, 2010; Brenneman et al., 2010; Gallard et al., 2010; Obama, 2009) and aids in developing a well-rounded citizenry (Attewell, Lavin, Domina, & Levey, 2006). Others who support the courses still recognize the need for change: better testing/placement measures, shortening of the developmental sequence, using corequisites, and strengthening the curricular alignment (Bailey et al., 2013) are recommended options. Finally, developmental programs should stay due to their causal impact on student retention and educational achievement (Attewell et al., 2006; Bahr, 2010; Bettinger & Long, 2005, 2009; Kolajo, 2010; Lesik, 2007).

This study utilizes aspects of the college impact model as a lens to conduct research.

Regardless of the arguments surrounding developmental education, colleges still offer the courses and students still need the training. Altbach et al. (2011) found that 40% of college students in the nation require at least one preparatory course. The Alabama Commission on Higher Education (ACHE, 2011) estimated that 34.4% of the high school graduates in 2010 reported taking at least one remedial course when they entered a public two-year or public four-year institution in the state. Further, the Birmingham, Alabama city school district, which is one of the lowest performing systems in the state, saw 50% of its 2010 college-going graduating class need remediation in these public postsecondary settings. And Alabama's averages are similar to most national figures (ACHE, 2011).

Conceptual Framework

This study utilized a framework provided by Terenzini and Reason (2005). From their extensive research on student decisions in the first year of college, they found that this time frame is a make-or-break period for many students. The approach they developed, labeled as a college impact model, identified influences from students, faculty, and institutions that have an impact on the first year of learning and persistence.

Concerning potential uses for this college impact model, Terenzini and Reason (2005) suggested that it would be an effective model for research pertaining to "the effects of academic departments" (p. 13). Therefore, this study utilizes aspects of the college impact model as a lens to conduct research. Following their model, outcome variables such as pass/fail status in the first college-level math class and graduation status were analyzed. The organizational context, the peer environment, and the individual student experiences are valuable considerations for future studies. By discovering whether their students fit the extensive research regarding relationships between student characteristics (precollege characteristics) and academic success (outcomes), faculty and administrators can make decisions regarding classroom experiences and other college environment experiences that best fit the needs of the students.

Methods

To conduct the research, students enrolled in MTH 100 (the first college-level math course at the participating institution) were divided into two mutually exclusive groups: (a) students needing developmental math before taking MTH 100, and (b) students who were exempt from developmental math before taking MTH 100. These two groups, along with interactions based on gender and race, were studied based on the pass/fail status for MTH 100 and graduation status. If a student took MTH 100 more than once, the higher(est) grade earned was kept and all other records were discarded.

The following constitutes the research questions used in this study.

1. Do interactions exist between pass/fail status in MTH 100 and gender, race, and assignment to developmental math?
2. Do interactions exist between graduation status and gender, race, and assignment to developmental math?

The data used in this study was from students enrolled in MTH 100 during the period beginning fall semester 2002 and ending summer semester 2013, which amounted to 10,003 students.

For both research questions, developmental status, gender, and race were independent variables. For the dependent variables of pass/fail status in MTH 100 and graduation status, logistic regressions were used. The records generated were transferred to a statistical analysis software package (SPSS) in order to run tests and analyze results. The value of $p < .05$ was used as the significance level for all tests performed.

This study was limited to data collected from records of Fall 2002 through Summer 2013. This study was also limited to a rural, public two-year system in Alabama, which restricts the ability to generalize the results to all types of higher education institutions. Items such as course design, teaching methodology, student goals, external influences, and student motivation potentially play a role in student performance and success and would be excellent variables for future studies, yet the scope of this study does not incorporate these factors.

Findings

The following constitutes a discussion of the results of both research questions. The assumptions are as follows: (a) the dependent variable is dichotomous; (b) there are one or more independent variables that are either continuous or categorical; (c) observations are independent, mutually exclusive, and exhaustive; and (d) a linear relationship exists between any independent variables and the dependent variable. Regarding pass/fail status in MTH 100, the linearity assumption was violated as evidenced by a significant Chi-Square ($p < .001$). Therefore the data do not fit the model. To minimize Type I errors due to this violation, a confidence level of .01 was used for this analysis only. For the graduation analysis, all assumptions were met, so a confidence level of .05 was used. Table 3 provides the logistic regression results.

Table 1
Population Characteristics

Characteristics	Developmental Math Students	Non-developmental Math Students	Total/Avg
Total number (%)	4656 (46.5)	5347 (53.5)	10,003
Male students (% of all males)	1572 (41.8)	2188 (58.2)	3760
Female students (% of all females)	3084 (49.4)	3159 (50.6)	6243
Average age	26.0	23.1	24.6
Average GPA	2.84	2.71	2.78
Average COMPASS math subtest	81.73	92.21	86.97
Average ACT math subtest	19.03	19.70	19.37

Part One: Interaction Effects on Pass/Fail Status in MTH 100

A logistic regression was done to determine whether gender, race, or developmental status were predictors of pass/fail status in MTH 100. Six cases were removed: those students enrolled in the class as audit status (three) or withdrew passing (three). The logistic regression model was statistically significant, $x2\ (3) = 157.937$, $p < .001$. The model correctly classified 72.5% of the cases. In other words, 72.5% of the variation in passing/failing MTH 100 can be attributed to the variation in the combination of gender and race. Gender and race had significant partial effects ($p < .001$ for each). Females had higher odds of passing MTH 100 than males. White students had higher odds of passing than non-White students. The logistic regression equation was ln(ODDS) = .352 + .424(GENDER) + .473(RACE) - .002(DEV_STATUS).

Part Two: Interaction Effects on Graduation Status

A logistic regression was performed to determine whether gender, race, or developmental status were predictors of graduation. There were 252 duplicate cases where students earned more than one degree or certificate and only the first credential earned per student was used in the analysis. The logistic regression model was statistically significant, (3) = 78.496, $p < .001$. The model correctly classified 74.7% of the cases. In other words, 74.7% of the variation in graduation status can be attributed to the variation in the combination of gender, race, and developmental math placement. Gender, race, and developmental status had significant partial effects. Odds of graduating were higher for females, non-White students, and students placed in developmental mathematics, meaning they were more likely to graduate. The logistic regression equation was ln(ODDS) = -1.021 + .309(GENDER) - .200(RACE) - .206(DEV_STATUS).

Table 2
Data Collected and Codings

Item	Data Collected and Relevant Codings
1	Semester and year enrolled in MTH 100
2	Student number
3	Grade earned in MTH 100 A passing grade (A, B, or C) was coded as 1. A failing grade (D, F, or W) was coded as 0.
4	Graduation Those who graduated or completed a program were coded as 1. Those who did not graduate or complete a program were coded as 0.
5	Gender Females were coded as 1. Males were coded as 0.
6	Race White students were coded as 1. Non-White students were coded as 0.
7	Developmental math status Non-developmental math students were coded as 1. Developmental math students were coded as 0.

Discussion

The goal of this study was twofold: to examine the link between developmental math classes and performance in Math 100, and to examine the relationship of developmental courses with student graduation. Our results indicate that at the institution studied the developmental offerings do in fact increase the likelihood ofcollege completion. In the first model, female and White students were shown to have higher likelihood of success in MTH 100; in an interesting difference, female students, students in developmental math, and non-White students all had higher odds of graduation.

These results reveal important considerations for the participating institution. Terenzini and Reason's (2005) college impact model shows

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Table 3
Logistic Regression Results

	B	Wald	Sig.	Exp(B)
MTH 100				
Gender(1)	.424	83.417	.000	1.529
Race(1)	.473	79.770	.000	1.604
Dev Status(1)	-.002	.002	.963	.998
Constant	.352	34.064	.000	1.422
Graduation				
Gender(1)	.309	38.908	.000	1.362
Race(1)	-.200	13.171	.000	.818
Dev Status(1)	-.206	13.391	.000	.814
Constant	-1.021	252.442	.000	.360

there are many sources of influence that enhance institutional effectiveness, which has more to do with what the institution does as opposed to what it is. Considering the peer environment, decision-makers can improve student success by accounting for the curricular, classroom, and out-of-class experiences that contribute to student learning. By understanding this aspect of the model, leaders can be mindful of how faculty decisions (somewhat regulated by the institution) and external factors (outside of institutional control) play a role in student learning, persistence, and success

Taking these items into consideration, the discussion of results that follow constitute a few of the variables leading to effectiveness. But, at a minimum, administrators can be mindful of how important, according to Terenzini and Reason (2005), the background characteristics, the organizational context, and the peer environment are to a student's chances for success.

Part One: Interaction Effects on Pass/ Fail Status in MTH 100

Research question one attempted to determine whether gender, race, or placement in developmental math courses predicted whether a student would pass MTH 100. The main effects of gender and race showed statistical significance, implying that these demographic variables could have an impact on a student's chances of success in the first college-level course (females and White students had higher odds of passing). This is important for administrators to be aware of, especially for those students who are at a disadvantage due to characteristics that are beyond their control. By being intentional about services offered to at-risk students, institutions can create an organization and peer environment (Terenzini & Reason, 2005) for students, which gives them a better chance at academic success. This is discussed in greater detail in the Implications section.

Perhaps just as interesting as what was significant, was what wasn't; having been placed into developmental math did not mean students performed significantly better or worse in MTH100 than those students who didn't place into developmental math. It would follow that, without developmental math, it could be assumed students placing into them would be underprepared for MTH 100. The fact that there is no significant difference between them and nonplaced students is encouraging. Again, though, the need to continue to probe reasons for the statistically lower odds for males and non-White students must be noted.

Having been placed into developmental math did not mean students performed significantly better or worse in MTH100.

Part Two: Interaction Effects on Graduation Status

Research Question two attempted to determine whether gender, race, or placement in developmental math courses predicted whether a student would graduate. The logistic regression model was significant, and each predictor showed statistical significance. The significance indicates there is some chance that gender, race, and placement in developmental math courses factored into the probability that the students in this study graduated; enrollment in developmental classes did increase the odds that females, non-White students, and developmental students would graduate. These are interesting findings. Developmental courses are often viewed negatively, but this study shows that they can play an incredibly important role in helping students graduate, improving their odds of graduating substantially.

So institutional decision-makers can be mindful of the trends in these demographic characteristics and implement policies and practices to help these students succeed. It is important to note here that many students who attend a community college do not necessarily have the goal of graduating. Certainly some enroll in efforts to earn a two-year degree, but many others attend with the intentions of transferring to a four-year institution, enhancing job skills, or workplace advancement. The credential of a two-year degree may be irrelevant and therefore students do not apply for graduation.

Implications for Theory and Practice

The literature discussed earlier pointed out that developmental classes have been around since the inception of American higher education (Breneman & Haarlow, 1998; Ignash, 1997; Keimig, 1983; Merisotis & Phipps, 2000), but many policymakers and administrators to date are pressuring institutions to remove the courses from the college realm (Adelman, 1996; Bahr, 2008, 2010; Blanchette, 1997; Hebel, 1999; McCabe & Day, 1998; Phipps, 1999). Since researchers lament that there are no efficient evaluation procedures to determine the effectiveness of these programs (Bailey, 2009; Bettinger & Long, 2005; Boylan et al., 1997; Calcagno & Long, 2009; Grubb, 2001), then many people do not see their worth. By providing possible explanations for student success, this research offers the participating institution data useful for making important decisions regarding whether or not to continue offering developmental mathematics courses. Since the students in this study who needed developmental math performed as well as or better than those students who entered ready for college-level work, there is a chance that the former group could have missed out on the opportunity of earning a higher degree had it not been for the training received in developmental mathematics.

The study at hand also presented an evaluation method of comparing performance indicators for students needing developmental math with those who did not need developmental math. The participating institution can continue to utilize this method in order to determine the ongoing effectiveness of the developmental classes (potentially for mathematics, English, and reading) and other institutions can use the study to evaluate their programs.

Another problem noted in the literature review addressed the vast number of students needing, and subsequent colleges offering, developmental mathematics courses. The goal of schools producing college-ready students should be to reduce those numbers of students needing developmental courses, although this study does show that developmental courses can play an important role

in helping students graduate. Thus, due to the high number of both students needing developmental courses and the number of institutions offering developmental courses, increased efficiency to enhance student success and proficiency should be the aim of any group vested in the education of the country's citizenry. Through this study, the results obtained are helpful in this area in that the effectiveness of developmental education at the participating institution was confirmed and potentially advanced the community.

Higher education institutions can team up with area high schools and build a bridge, so to speak, from high school to college. This partnership could provide basic information regarding how college works (admission process, applying for scholarships, developing schedules, importance of joining organizations, etc.). Additionally, precollege teachers could be trained concerning subject-specific college-level skills necessary for students to learn, as well as behavior-specific qualities (e.g., responsibility, punctuality, and participation) that contribute to academic success. It would also be beneficial to target students as they enter high school in order to educate them regarding college options, the college process, and how their short-term decisions affect their future.

Finally, the partnership could work toward providing the exiting high school seniors with a crash course in necessary subject-specific skills before taking the college placement exam. By doing this, students can hopefully brush up on those skills and begin at the right point for their level of knowledge, which in turn reduces the number of students needing precollege training upon entering postsecondary education. The results of this study identified characteristics of students in the institution's service area that could be intentionally provided with these interventions. Testing levels of college readiness and core subject skill levels, particularly prior to senior year to allow for students to receive help and develop in these areas, would be helpful. So too would intense counseling or advising about developmental education.

Administrators can make note of the important results that appeared in the analyses to determine the relationship between developmental status and graduation status. Since this relationship was statistically significant, taking developmental mathematics could be a factor that helps students graduate. This might be attributed to the fact that the rigor of the developmental math class(es) prepares students for the workload to expect in subsequent courses in their programs, and therefore passing the developmental math class(es) paved the way for doing well in future courses. Or perhaps soft skills were developed in these training courses that students utilized in subsequent coursework. Thus administrators can utilize the results here in making claims in favor of keeping developmental mathematics at the participating institution.

After conducting the research presented in this study, additional approaches on this topic are warranted. First, research suggests that many institutions are not evaluating the developmental programs in an adequate manner (Bahr, 2008; Boylan & Saxon, 2010; Boylan et al., 1997; Breneman & Haarlow, 1998; Calcagno & Long, 2009; Collins, 2010; Grubb, 2001). Developmental reading and developmental English classes could evaluate the effectiveness of their courses using this remediated-exempted design.

Second, many programs at two-year institutions accept technical math (MTH 116-Basic Mathematics with Applications at the participating institution) for program requirements. A similar study could be designed to analyze student characteristics and performance in credit-bearing gateway courses and developmental courses, since some students need a developmental class.

Administrators can utilize the results here in making claims in favor of keeping developmental mathematics at the participating institution.

Conclusion

This study provided possible explanations of success based on explanatory variables, such as developmental mathematics classes, that could have predicted student success. By understanding the results herein, administrators have valuable data on background characteristics and demographics that contribute to academic success, and these officials can be intentional on implementing policies and forming groups that meet these needs. Additionally, this study revealed an evaluation model for the institution (using enrollment data already collected) that can be replicated in the future for purposes of ensuring program effectiveness. The results formed by this analysis provided a glimpse into a developmental mathematics program at a small, rural two-year institution in Alabama that seems to be doing what it takes to help students succeed. There is a need for a much closer look at developmental education in this country: why is the need for developmental education so high, why is it so prevalent, how should we measure its effectiveness, and how do we best make it beneficial to those who need the training? Although this study did not provide an intensive design that is generalizable to all institutional types and programs, the various relationships explored were important and warrant further study.

Since there is no agreed-upon means to evaluate the effectiveness of developmental programs to date, it is difficult for an institution to look at what its skills training courses are doing and decide whether they are helpful or being completed in a satisfactory manner. Because college performance paves the way for predicting socioeconomic outcomes (Kerckhoff, Raudenbush, & Glennie, 2001), administrators and practitioners cannot overemphasize the importance of this issue. Knowing the characteristics that potentially contribute to student success can be valuable to an institution in terms of how it designs classroom environments and how it creates peer experiences.

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Knowing the characteristics that potentially contribute to student success can be valuable to an institution.

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