Success and Persistence of Developmental Mathematics Students Based on Age and Ethnicity

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This ex post facto study examined the fall-to-fall persistence and academic success of students in a medium-sized Virginia community college. The variables of age and ethnicity in combination with whether a student's first mathematics course was developmental were used to examine the effects of each. It was found that neither the interaction of developmental status and age nor the interaction of developmental status and ethnicity were significant in predicting either success in the first college-level mathematics course or persistence to a second year. Developmental students who subsequently enrolled in a college-level mathematics course had comparable levels of success as did students who did not require developmental mathematics courses. Older students and White students were more likely to succeed in their first college-level mathematics course than were traditional-age and non-White students, respectively. There were no significant differences based upon age, ethnicity, or developmental status in the persistence to a second year of enrollment in the college.

Background

Developmental education is receiving an increasing amount of attention, particularly in community colleges. President Obama has provided significant funding for community colleges with the expectation that more students will graduate. Community colleges enroll 35% of postsecondary students in the country at a cost of over $38 billion yearly (Provasnik & Planty, 2008). As the great majority of community colleges have an open admissions policy, one of the key educational tasks that has fallen to community colleges is developmental ed-

ucation (Provasnik & Planty). With open admissions policies, students often enroll with weak academic skills that are not to the level expected of college students. Developmental courses in college are present to bring the academic level of the student up to the collegiate level (Johnson & Kuennen, 2004; VCCS, 2009). The success of developmental students is critical in reaching national, state, and institutional goals on student success (VCCS, 2011), particularly as approximately 40% of community college first-year students enroll in at least one developmental course (Alliance for Excellent Education, 2011; Parsad, Lewis, & Greene, 2003).

In 2008, the Virginia Community College System created a Developmental Education Task Force that examined the state of developmental education in its 23-member community colleges. This task force affirmed three goals for the system of community colleges in Virginia: (a) to reduce the need for developmental education; (b) to redesign developmental education to allow for completion in less than one year; and (c) to increase the number of students graduating or transferring (VCCS, 2009). Data collected for this report showed that 56% of first-time-in-college students beginning in the fall 2006 semester received recommendations for developmental mathematics courses based on their placement scores. Since the date of that report, the percentage of students placing into developmental courses has increased in Virginia (VCCS, 2011) and has been demonstrated to be increasing in other areas of the country as well (Kendall, Pollack, Schwols, & Snyder, 2007).

The Virginia Community College System collects data to determine to what level it is reaching the stated goals created by the Developmental Education Task Force. These goals include measures of student success. The measures used to determine how these goals are being met include the persistence of students from fall to spring and fall to fall semesters, success in developmental courses, success in college-level courses, graduation rates, and transfer rates. This study examines two of these measures: (a) persistence of students from the fall semester of 2006 to the fall semester of 2007 and (b) the success students had in their first college-level mathematics course. This study extends the data reported by the VCCS by examining age and ethnicity in conjunction with developmental status to determine if there are different results for student groups commonly found in community colleges: nontraditional and ethnically diverse students. Specifically, this study was guided by the following research questions: (a) What is the direct impact of developmental status, age, and ethnicity on the successful completion of the first college-level mathematics course attempted by the student as well as the fall-to-fall persistence

of the student; (b) and are there any two-way interaction effects among developmental status and age, or developmental status and ethnicity?

Review of Literature

Developmental education has been part of education in the United States for almost 400 years as Harvard was founded in 1636 in part to teach remedial reading to adults (Dotzler, 2003), and has been a formalized area of study since the early 1900s. President Obama provided $12 billion to community colleges (Marklein & Gray, 2009) expecting reform to help increase graduation. The influx of students will increase the need for developmental education, as the percentage of community college students who enroll in at least one developmental course has been approximately 40% for the past 10 years (Alliance for Excellent Education, 2011; Parsad, Lewis, & Greene, 2003). Without developmental education approximately 2 million students would drop out of college (Higbee, Arendale, & Lundell, 2005).

The financial costs, which include faculty, support services, and physical space, of developmental education, have been estimated to be over $5 billion (Alliance for Excellent Education; Bahr, 2008). There is concern that the outcomes of developmental education do not reflect the investment. Over 75% of developmental students ultimately do not complete a degree (Bahr; VCCS, 2011). Higher education has received increased scrutiny over the past several years, and developmental education is currently being examined closely throughout the country (VCCS, 2009). This close examination is leading to major changes in developmental education (Gonzales, 2011; Mireles, 2010)

Success of Developmental Students

One of the difficulties in discussing success for community college students is the different definitions of success that are used by researchers. One traditional definition of success in higher education is graduation rate. However, community colleges typically have very low graduation rates. Many community college students measure their own success in different ways than graduation, whether that means transferring to another institution, obtaining a certificate, or simply completing a number of courses. Additionally, one of the best predictors of success in higher education is performance in high school (Yates, 2010), a factor that is very difficult to attribute to differences in community college programming. Researchers consistently report that among students who require developmental work, many of these students do not successfully complete their

developmental work and the graduation rate for developmental students is particularly low (Alliance for Excellent Education, 2011; Bahr, 2008; Yates, 2010).

It is also common among researchers to discuss the success of developmental courses by comparing the outcomes of college-level mathematics courses of students who first enrolled in a developmental mathematics course with the outcomes of students who did not require developmental work. It is this definition this study will employ to determine the success of students. Success will be defined as receiving an A, B, or C in the course, which is the definition used by the VCCS in their Developmental Education Annual Report (VCCS, 2011).

Most statistical studies using diverse samples have reported no difference among developmental and nondevelopmental students when comparing success rates in college-level mathematics courses (Bahr, 2008; Calcagno, 2007; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). While there are studies that have reported different results, these studies generally do not statistically examine a diverse sample. For example, the Virginia Community College System (VCCS, 2011) reported developmental students succeeded at lower rates than nondevelopmental students by using descriptive statistics without examining statistical significance, and Dubray (2005) reported developmental students had greater success than nondevelopmental students by examining urban developmental students who began their developmental coursework at the lowest level of remediation who then completed three levels of developmental courses and a college-level course.

Bahr (2008) remarked upon the similarity of developmental and nondevelopmental students in degree attainment and transfer by saying "it indicates that remediation has the capacity to fully resolve the academic disadvantage of math skill deficiency, at least as far as these outcomes are concerned" (p. 442). It should be noted, however, that the similarity of success rates are for developmental students who complete their developmental coursework and enroll in a college-level course. The majority of students who require developmental mathematics never reach a college-level mathematics course (Bahr; Roksa et al., 2009).

Persistence of Developmental Students

Improving the persistence of students is a goal for colleges for financial and planning reasons (Tinto, 1993). Research indicates more than half of the students who drop out of college do so during their first year (Tinto)

and close to half of all community college students drop out before obtaining their degree (Calcagno, Bailey, Jenkins, Kienzl, & Leinbach, 2008; Fike & Fike, 2008). Tinto (1993) has created a model of persistence in higher education that states persistence increases when students are socially integrated into the school but he questioned whether social integration mechanisms were applicable to commuter and community college students. Recent research has shown persistence in community colleges can be increased by social integration similar to traditional four-year colleges (DuBray, 2005; Karp, Hughes, and O'Kara, 2008). Tinto said "nowhere is the importance of student involvement more evident than in and around the classrooms of the college" (p. 132). In many community colleges, and particularly in Virginia community colleges, developmental courses meet for longer periods of time than college-level courses and often have fewer students in each section. These smaller class sizes and the special attention students receive may be keys to retaining developmental students (Waycaster, 2001). Fike and Fike supported this possibility as they found student retention and successful completion of a developmental mathematics course were positively correlated.

Researchers have reported developmental education does not harm the persistence of students, and some have shown developmental mathematics education improves persistence (Fike & Fike, 2008; Lesik, 2007; Waycaster, 2001), particularly for minority groups. Calcagno (2007) and Moore (2006) reported similar levels of persistence between developmental and nondevelopmental students. More study is needed on the persistence of students to better understand this phenomenon, particularly studies that examine the general student bodies of community college students. Many researchers, including those reviewed for this study, do not examine the general community college student body. Particularly, Lesik and Moore examined four-year college students, Calcagno examined only students at the cutoff for developmental work, and Waycaster examined 15 individual classes. Examining persistence of students from an entire cohort of students at a college will provide a more complete understanding of the persistence of community college students.

Age and Ethnicity of Developmental Students

There is a great diversity of students in community college (Cohen & Brawer, 2008). This diverseness creates student needs as varied as their differences. These needs include access, workforce and economic development, comprehensive programming, quality and excellence, responsiveness to needs, specified service areas, and diversity (Ayers, 2002), and

they differ for students of different ages and ethnicities. Ayers also reported that themes of access and quality were among the top priorities of community colleges in the South. Providing quality at the same time as access to a diverse range of students requires examining current results and ensuring that the needs of each group of students are being met.

Ethnically diverse students have been found to be overrepresented in developmental education (Alliance for Excellent Education, 2011) and have generally been found to be less successful in developmental courses than White students (Dubray, 2005; Fike & Fike, 2007). Older students have also been found to be more successful in developmental courses than traditional-age college students (Calcagno et al., 2008; Dubray; Fike & Fike). However, Corey Legge (2010) reported that neither age nor ethnicity was related to student success. Understanding the relationship of age and ethnicity to student success and persistence can help direct resources to meet the demands of the public to create successful programs and more college graduates.

Developmental Education in Virginia

The Developmental Education Task Force described a turning point in developmental education in Virginia community colleges. It said developmental education in Virginia was no longer about access but about improving the success and experiences of developmental students. To ensure improved student success and experiences, the task force recommended redesigning developmental courses, working with high schools to improve student readiness, improving student support services, and collecting data on first-time-in-college students to help ensure accountability at the college and state level (VCCS, 2009). The Developmental Education Annual Report (VCCS, 2011) is the first compilation of data to support the achievement of these goals recommended by the Developmental Education Task Force. The Developmental Education Annual Report described the 2006 cohort of first-time-in-college students and provided descriptive statistics about this cohort on measures designed to address the recommendations. Understanding which developmental students are struggling to meet standards will help the Virginia Community College System better direct funds and other resources to aid students and to achieve the Developmental Education Task Force goals. This study extended the knowledge from the descriptive statistics presented about the 2006 cohort from the Annual Report and statistically examined the differences between developmental and nondevelopmental students and their success in the first college-level mathematics course taken and their

persistence into a second year of college using additional variables of age and ethnicity.

The purpose of this quantitative study was to examine the effect of age and ethnicity together with developmental mathematics education in Virginia community colleges on students' persistence to a second year and academic performance in the students' first college-level mathematics course. This study utilized data from one medium-sized Virginia community college used by the Virginia Community College System in their report: *Developmental education annual report: Tracking the fall 2006 cohort and five-year historical trends* (VCCS, 2011).

Methodology

This study utilized ex post facto data to examine students who first enrolled in a medium-sized community college in Virginia during the fall 2006 semester and followed those students through the spring 2011 semester. The time frame for this particular sample was chosen to allow data to be collected from a five-year period to not only measure fall-to-fall persistence but also to allow students whose first mathematics course is developmental to have time to also enroll in a college-level course for comparisons to students who are not required to enroll in a developmental course.

Records of students who were first-time-in-college students from the chosen community college during the fall 2006 semester (n = 995) were examined to ensure all students met the criteria for this study. Students (n = 53) who were ages 15 and 16 were eliminated from the study as they did not meet the age criteria for either traditional- or nontraditional-age students. Students (n = 186) who did not take either a developmental or college-level mathematics course during their first semester, fall 2006, were eliminated as it would not be possible to examine fall-to-fall persistence based on the type of mathematics course taken. This gave a final sample size of n = 756 students.

Data collected from the college for each student included the student's age, gender, ethnic group, enrollment status for the fall of 2007, and every mathematics course taken with the grade received in the course. Dichotomous variables were created to reflect inclusion as a nontraditional-age student (23 or older), a non-White ethnicity, developmental status based on first mathematics course taken, success based on receiving a grade of A, B, or C in the first college-level mathematics course taken, and persistence based on their enrollment status for the fall 2007 semester.

Nontraditional students were defined as 23 and older based on the definition used by the Virginia Community College System (VCCS, 2011). Ethnicity was defined dichotomously, White and non-White, due to low numbers in all non-White ethnic and racial groups other than Black/African American. The total of 301 non-White students included ethnic and racial groups of Black/African American (227 students), Hispanic/Latino (39), Asian (23), American Indian/Alaska Native (8), and Native Hawaiian/Other Pacific (4).

A binary logistic regression can be used to identify variables associated with being in one condition or another, particularly with an output variable that has only two possible outcomes (Meyers, Gamst, & Guarino, 2006). As the dependent variables in this study, persistence and success, are dichotomous, logistic regression was used to determine effects. A logistic regression for both dependent variables persistence and success was performed using the independent variables of developmental status, age, and ethnicity to determine if there were significant interaction effects. Additionally, a logistic regression was performed using all three independent variables and the interaction variables developmental*age and developmental*ethnicity to determine if there were any two-way interaction effects in determining the persistence or success of students.

This study examines the impact of developmental status, age, and ethnicity on the successful completion of the first college-level mathematics course attempted by the student as well as the fall-to-fall persistence of the student. Impacts were determined using direct as well as interaction effects among developmental status, age, and ethnicity.

Analysis

A total of 995 students were classified as first-time-in-college students in a mid-sized Virginia Community College during the fall 2006 semester. This study examined a sample of 756 students from this group who were 17 or older and enrolled in either a developmental or college-level mathematics course their first semester. Of this sample, 24% of students succeeded in their first college-level math course, 27% did not succeed, and 49% did not attempt a college-level math course (i.e., first enrolled in a developmental course but never enrolled in a college-level course). A total of 50.3% of students persisted to a second year; the first math class for 68% of students was a developmental class, 10% of students were nontraditional age, and 40% were of non-White ethnicity.

The majority of developmental students never attempted a college-level mathematics course (72.2%). For students who attempted a college-level mathematics course, the descriptive statistics showing the number and percentage of students who succeeded in their first college-level mathematics course are provided in Table 1.

College-level students (52.2%) and developmental students (49.3%) persisted at statistically similar rates. These similarities held true for students of different ages and ethnicities. Descriptive statistics for persistence are provided in Table 2.

A logistic regression was performed using a dependent variable of success and independent variables developmental status, age, and ethnicity. This model was able to provide a statistically significant improvement in predicting success over the constant-only model ($\chi 2$ (3, 756) = 11.319, p = .010, estimated $R2$ = .040) in the first mathematics course taken. The predictor variables ethnicity (Wald (1,731) = 6.674, p = .010) and age

Table 1. Descriptive Statistics for Success in First College-Level Mathematics Course

Variable	Category	Succeeded (%)	Did Not Succeed (%)
Developmental Status	Developmental	75 (52.8%)	67 (47.2%)
	College-Level	130 (53.1%)	115 (46.9%)
Age	Traditional (17-22)	181 (51.3%)	172 (48.7%)
	Nontraditional	24 (70.1%)	10 (29.9%)
Ethnicity	White	140 (56.9%)	106 (43.1%)
	Non-White	57 (44.1%)	72 (55.9%)
Total Sample		205 (53.0%)	182 (47.0%)

Table 2. Descriptive Statistics for Fall-to-Fall Persistence

Variable	Category	Persisted (%)	Did Not Persist (%)
Developmental Status	Developmental	252 (49.3%)	259 (50.7%)
	College-Level	128 (52.2%)	117 (47.8%)
Age	Traditional (17-22)	341 (50.2%)	338 (49.8%)
	Nontraditional	39 (50.6%)	38 (49.4%)
Ethnicity	White	221 (51.4%)	209 (48.6%)
	Non-White	146 (48.5%)	155 (51.5%)
Total Sample		380 (50.3%)	376 (49.7%)

(Wald (1,756) = 5.383, p = .020) were found to be significant predictors of success, while the variable developmental status (Wald (1,756) =

.082, p = .775) is not significant in predicting success. Another way of reporting the effects of the significant variables is to use odds ratios and probability ratios. The odds of nontraditional-age students succeeding in their first college-level mathematics course are 2.55 times the odds of traditional students being successful. Calculating the probability ratio for the two groups shows nontraditional students are 1.36 times as likely to succeed as are traditional students.1 Similarly, the odds of non-White students succeeding in their first college-level mathematics course are .56 times the odds of White students being successful and the probability ratio shows White students are 1.29 times as likely to succeed as are non-White students. Table 3 presents the regression coefficients (B), the Wald statistics, significance level, odds ratio [Exp(B)], and the 95% confidence intervals (CI) for odds ratio for each predictor.

Table 3. Logistic Regression Results for Predicting Success in the First College-Level Math Course

						95% CI for Exp(B)	
Step	Variable Entered	B	Wald	Sig.	Exp(B)	Lower	Upper
1	Developmental	-.063	.082	.775	.939	.610	1.445
	Ethnicity	-.578	6.674	.010	.561	.362	.870
	Age	.938	5.383	.020	2.554	1.157	5.638
	Constant	.246	2.669	.102	1.278		

A logistic regression was performed using a dependent variable persistence and independent variables developmental status, age, and ethnicity. This model did not provide a statistically significant improvement in predicting fall-to-fall persistence over the constant-only model (2 (3, 756) = 1.456, p = .692, est $R2$ = .003). The predictor variables ethnicity (Wald (1,731) = .544, p = .461), age (Wald (1,756) = .368, p = .544), and developmental status (Wald (1.756) = .566, p = .452) are not significant in predicting persistence. Table 4 presents the regression coefficients (B), the Wald statistics, significance level, odds ratio [Exp(B)], and the 95% confidence intervals (CI) for odds ratio for each predictor.

To test if age or ethnicity moderates the effects of developmental status on the success and persistence of community college students, two additional models were created. These models included the two-way interaction terms developmental*age and developmental*ethnicity. Two logistic regressions were then performed. The logistic regression with the dependent variable success found there is no significant interaction between developmental status and age (Wald (1, 756) = 1.932, p = .080)

1 See Osborne (2006) for a discussion comparing Odds Ratio and Probability Ratio

or between developmental status and ethnicity (Wald (1, 756) = .056, p = .813). The logistic regression with the dependent variable persistence found there is no significant interaction between developmental status and age (Wald (1, 756) = .379, p = .538) or between developmental status and ethnicity (Wald (1, 756) = 1.969, p = .161).

Table 4. Logistic Regression Results for Predicting Fall-to-Fall Persistence

						95% CI for Exp(B)	
Step 1	Variable Entered	B	Wald	Sig.	Exp(B)	Lower	Upper
	Developmental	-.120	.566	.452	.887	.648	1.213
	Ethnicity	-.112	.544	.461	.894	.663	1.205
	Age	.151	.368	.544	1.163	.715	1.891
	Constant	.121	.748	.387	1.128		

Conclusions

This study found no significance interaction effects between developmental status and age or developmental status and ethnicity on either the success of a student in their first college-level mathematics course or on the student's persistence to a second year of college. Specifically, developmental students who are nontraditional age have similar levels of success and persistence as do traditional-age students. Likewise, developmental students whose ethnicity is non-White have similar levels of success and persistence as do White students.

The most notable finding of this study was that the developmental status of students is not a significant factor in either the success in the first college-level mathematics course or fall-to-fall persistence. This result differs from the Developmental Education Annual Report (VCCS, 2011), which reported developmental students persisted at higher rates and succeeded at lower rates than nondevelopmental students. The difference could be the VCCS report used descriptive statistics for their report while this study performed statistical analysis to determine significant differences. Another possible explanation is the current study examines only one VCCS school. There may be differences in the sample between this individual school and the compilation of all 23 Virginia community colleges.

Bahr (2008) reported similar findings when studying the success of developmental students and noted: "When remediation works, it works extremely well" (p. 444). However, a large percentage of developmental students never reach a college-level course. In the current study, 72% of developmental students in the population never attempted a college-level

mathematics course. These students either did not successfully complete their developmental sequence, or completed it but did not attempt a college-level course. More research is needed to determine the reasons developmental students do not attempt college-level mathematics.

Two factors that were significant in determining the success of students were age and ethnicity. A nontraditional-age student is 1.36 times as likely to succeed as is a traditional-age student. A White student is 1.29 times as likely to succeed as is a non-White student.

There are no significant differences between developmental and nondevelopmental students, traditionally or nontraditional-age students, or students from different ethnicities in fall-to-fall persistence. This result seems to refute the findings of Waycaster (2001) and Lesik (2007) who found that developmental students persisted at higher levels than nondevelopmental students and supports the findings of Calcagno (2007) and Moore (2006).

Recommendations

Developmental education at this particular Virginia community college successfully raises the level of students to that of college-ready students. In this regard, developmental mathematics education is successful. There are also no significant differences between students of different ages and students of different ethnicities in the developmental mathematics program. In other words, older and non-White students find just as much success as their dominant group counterparts. Programs that direct resources toward these groups do not need to be expanded.

Significant differences were found in the success rates of nontraditional-age students and minority students irrespective of their developmental status. Specifically, traditional-age college students and minority students find lower success in college-level mathematics than do older and White students. These differences occur in both developmental and nondevelopmental students. Therefore, administrators should examine programs that can increase student success for older and non-White students.

The VCCS articulated three goals as it examined developmental education in the state community colleges (VCCS, 2009). The first of these goals, reducing the need for developmental education, would provide the greatest increase in student success. Past research has consistently reported that a major contributing factor to traditional-age students and Black students having lower rates of success is a poor preparation for higher education from the secondary school systems in the United States (Alli-

ance for Excellent Education, 2011; Bailey, Jeong, & Cho, 2010; Martino & Wilson, 2009; USDOE, 2006).

Community colleges, county and city school boards, and communities should consider working together to identify ways to better educate instructors and students in secondary schools as to the level of knowledge expected for success in higher education.

Students who successfully completed their developmental coursework were not significantly different with regard to success than those students who did not need developmental courses; however, the vast majority of developmental students never attempted a developmental course. So while developmental mathematics is successful for those students who complete it, there is a large number of students who do not complete the developmental sequence. More study is needed to determine why students do not complete their developmental coursework. An ex post facto framework would not be appropriate to determine the reasons developmental students do not succeed in their developmental coursework. While it may not be possible to assist every student to become college ready, a better understanding of why students do not complete developmental work will help the college proactively address important student issues.

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