Predicting Bachelor's Degree Attainment for Developmental Math Students

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This study used the National Educational Longitudinal Study: 88 /2000 (NELS 88: /2000) dataset to explore characteristics associated with college degree attainment. The study was informed by Ajzen's Theory of Planned Behavior. The sample size was 6,832 postsecondary students. The findings revealed that developmental math students were less successful in obtaining a degree than students not taking developmental math. However, a relatively large percentage of developmental math students were successful in obtaining a degree. In addition, factors including 10th grade math competence, socioeconomic status, and 10th grade beliefs about the ability to control life events were key predictors of degree attainment.

McCabe (2000) reported that 62% of all developmental education math students are in need of improvement in math skills compared to approximately 38% in reading and 45% in writing. A study conducted by the Conference Board of Mathematics found math enrollment up in all pre-college courses except for arithmetic and basic skills (Lutzer, Rodi, Kirkman, & Maxwell, 2007) an indication that basic algebra and intermediate algebra are where developmental math enrollments are increasing. In fact, for the last two decades, the effort to articulate the high school math curriculum with college standards appears to have failed; students appear to be less prepared than ever to successfully complete college algebra or college math (Crist, Jacquart, & Shupe, 2002). For these students, college algebra can become the gateway to a bachelor's degree. Additionally, students' high school course selection was described by Crist, et al. (2002) as "floating" (p. 4) with still too many students not taking the courses that would increase their chances for postsecondary academic success. For these students, developmental math is critically important.

The best predictor of college math performance is high school math performance, and college math performance can determine access to upper division courses and bachelor's degree completion. Trusty and Niles (2003) found an association between rigorous high school math courses and degree attainment. Adelman (1999) also found that the highest math course taken was an excellent predictor, with students taking math beyond Algebra II doubling their chances of degree attainment. This finding was true for all students, including students from low income families. Additionally, Adelman (1999) found that high school transcripts (r=.54) were a better predictor of degree completion than SAT or ACT (r=.48) scores. However, high school grades are subject to inflation and contain multiple confounding factors, such as teachers teaching out of discipline (Cizek, 2000). To exacerbate the problem, grade inflation interacts with poverty. Ziomek and Svec (1997) reported that when in college, those students from public schools with 75% participation in free or reduced lunch and who received A's in core subject areas performed the same as students from more affluent school districts making C's and D's in the same core subject areas. The conclusion is that students' high school math achievement is critically important to later math study, and the rigor of the high school academic experience shapes the college experience.

Conceptual Framework

The Student Integration Model (Tinto, 1988) and the Student Attrition Model (Bean, Partanen, Wright, & Aaronson, 1989) have dominated studies of students' attitudes about postsecondary study and the postsecondary experience. According to Burley's (2008) ideas about the Developmental Education Innovative Research Imperative (DEIRI), more robust social psychological theories are worth examination. Bandura (1997) theorized that the thought processes that precede and lead to human behavior (or performance) are mediated by perceptions of capability. This means that a person's attitudes about his or her behavior or performance could be a better predictor of future performance than past actual performance. Similarly, Ajzen's Theory of Planned Behavior (2002) suggests that behavior is the result of two factors: intention to do the behavior and actual behavioral control. Intention is mediated by perceived behavioral control, subjective norms (feelings of significant others about the behavior); and attitudes about the behavior. A good example of behavioral control is the notion that if one works hard, he or she can learn a difficult math task. Therefore, positive attitudes about math performance, positive attitudes from significant others concerning math performance, and positive attitudes about controlling the outcome of the math learning context can be better predictors than actual past math achievement.

In fact, negative attitudes about math performance can suppress math scores. For example, math anxiety and other apprehensions about math performance can significantly reduce math performance, specifically when speed is introduced as a factor (Cates & Rhymer, 2003). Additionally, Cates and Rhymer found that students who performed math operations more slowly and less accurately than a comparison group were less apt to choose additional math work, had difficulty with higher math concepts, and presented significantly more math anxiety. Perhaps the most pernicious example of the power of attitude in math study and testing is stereotype threat, where students' internalize ideas about racial and gender stereotypes. This can cause students' math achievement to suffer (Steele & Aronson, 1995). Therefore, poor math achievement can be much more complex than a skill deficiency.

An underlying principle for many psycho-social theories is that an examination of past social, psychological, and cognitive behaviors can be used to predict future behavior. In the case of developmental math students, an improved understanding of their psycho-social pasts should lead to more effective early interventions before students enroll in college. Also, the practice of developmental education could be informed by a better understanding of developmental education students beyond what is ascertained from diagnostic tests.

For this study, we chose variables that represent students' attitudinal state, math skill, and socioeconomic status (SES) as predictors of student success. All were assessed before students entered college. Included with these variables as part of the students' past profile was whether they had enrolled in developmental math at any time during their collegiate programs of study. The research question for this study is as follows: Will the linear combination of the attitudinal, skill, and contextual (SES and developmental math) variables predict student success?

Methods

Procedures

A correlational research design was used to examine the relationships among the predictor variable and the criterion variable (Gay, Mills, & Airasian, 2006). The data for this study came from the National Educational Longitudinal Study: 88/2000 (NELS: 88 /2000) dataset (public data) released by the National Center for Education Statistics in 2001. These data were collected at the behest of the U.S. Congress and released in public and restricted forms for use by educational researchers. The subjects in this study were a national sample of 8th graders who were surveyed in person or by phone in 1988, 1990, 1992, 1994, and 2000, using a multi-stage sampling technique, rather than simple random sampling. The data in this study come from the 1990, 1992, 1994, and 2000 survey waves. The sample size for the 2000 survey wave was 12,144; however, only 6,832 of these students attempted college by 1994, the year students were surveyed about developmental education. This sample is representative of 1,610,536 U.S. citizens who were in the 8th grade in 1988.

Variables

The first group of predictors includes attitudes of parents, teachers, and peers concerning earning a college degree (as reported by the student); 10th grade locus of control, and 10th grade self-concept. All of these predictors were gathered during the 1990 survey wave. These variables represent key features of the Theory of Planned Behavior and are based on self-report. The socioeconomic status (SES) variables were the second group of predictors in the study, including, percentage of students on free lunch in each high school in the study, income of parents, and the number of years of schooling students' mothers had completed. Other predictors include whether a student took developmental math, urban nature of the high school attended, high school math graduation requirements, and a math competence variable. This was a standardized math test created by the Educational Testing Service (ETS) for the National Educational Longitudinal Study and administered during students' 10th grade year. The criterion, the measure of success for this study, was whether students received a bachelor's degree. This type of criterion was also suggested by the DEIRI. The data were analyzed using SPSS (v12) and AM (Beta) statistical software packages. (AM is statistical software specially designed for data derived from multistage (complex) sampling techniques.)

Results

In this dataset, 18.6% of students self-reported taking developmental math, while 81.4% reported not taking such a course. However, 40% of students' transcripts listed a developmental education course, with 73.3% needing math remediation. By the year 2000, 41% of those who self-reported taking a developmental education math course had completed a degree compared to 55.7% of those who reported not taking a developmental course.

It is interesting to note that developmental math students reported higher postsecondary grades than those not needing developmental math. For example, 20.5% of developmental math students reported having earned mostly B's and C's compared with 12.9% of students not taking developmental math. Further, when it came to lower grades, 26.9% of developmental math students reported mostly C's and D's, while 30.4% of non-developmental math students reported these grades. More non-developmental education students reported the lowest grades (15%) than developmental math students (7.2%). A review of GPA's reported on transcripts indicated that non-developmental education students had GPA's of about 2.8 versus 2.3 for developmental education students. The authors do plan on exploring this finding further because these discrepancies may reflect on students' metacognitive awareness, self-confidence, and feelings of stereotype threat, all potential sources of grade suppression.

In a descriptive analysis of a key predictor, the 10th grade math standardized math score (year 1990), those students taking developmental math four years later or less (M=53.28, SD=15.80) scored much lower (on the 10th grade test) than those who did not take developmental math (M=59.11, SD=13.72). This test was based on a scaled score, which listed scores ranging from 31 to 72.

The final predictor variables were students' 10th grade standardized math test scores, socio-economic level, mother's education, percent of students on free or reduced lunch at the respondents' high school, locus of control, and whether students took developmental math. These variables were entered in the analysis in the order of the strength of their correlations with degree attainment. Other variables were omitted because of weak relationships with the criterion of degree attained.

Using an Adjusted Wald Test (The Adjusted Wald Test is a test of significance used with complex samples), the analysis produced a significant multiple R (R=.49), F(6,973)=273.13, p<.001. Cohen (1988) calls a correlation of .49 on the borderline between a medium and large correlation. Both R2 and r2 represent the criterion variance accounted for by the predictors. In this case, the model accounts for 24% of the variance in degree attainment, which is a significant amount of the variance in human performance to be explained. The best predictor of degree attainment for this group was the 10th grade math standardized score, followed by SES, percent of students on free or reduced lunch, locus of control, and mother's education level. Whether or not a student took developmental math was not a significant contributor to this regression model. However, this may be due to the presence of the strongest predictor in the model, the 10th grade math test score. Essentially, the developmental math participation variable and 10th grade math test score are measuring the same thing. If the student had weak math skills in the 10th grade, the chances of earning a bachelor's degree were diminished.

Two more analyses were run with degree attainment as the criterion variable, one analysis for those who had math remediation and the other for those who did not have math remediation. For those in developmental education, the best predictors were the 10th grade standardized math score, SES level, their mothers' years of education completed, locus of control, and urban nature of the high school (R=.403, R2=.163). For those students who did not need remediation, the predictors were simpler-- 10th grade standardized math score, SES level, and locus of control (R=.402, R2=.162). These subgroup analyses are also similar to the main regression analysis, indicating stability in the primary findings.

Discussion

Can a model based on the Theory of Planned Behavior help explain developmental math students' degree attainment in a national dataset? The answer is a qualified yes, with locus of control (a proxy for behavioral control) being the third best predictor of those selected. While we expected 10th grade math competence to be a strong predictor, the presence of three SES variables (a composite of parental income and education, the number of years of education parents had completed, and the percent of students receiving free lunch at school) is as eye-opening as it is troubling. The model that degree attainment =10th Grade Math score + SES composite + Parents' Education + Free Lunch + Locus of Control is nuanced and will be discussed below following a discussion of the descriptive analyses.

It is clear that developmental math students' skill deficiencies start early. Despite skill deficiencies that must have started prior to the 10th grade, 122,570 students (41% of all developmental math students) overcame these deficiencies to earn college degrees. This figure is impressive when viewed from a national perspective and is a measure of the practical significance of the developmental education experience, particularly when one considers that these students would not have had the chance to earn a degree without the benefits derived by taking developmental education courses.

Early math skill is still the best predictor of future success, as suggested by the literature (Adelman, 1999; Trusty & Niles, 2003); however, the power of poverty cannot be ignored. It is helpful to note that a review of the SES quartile data in the NELS dataset indicated a skew with students in the highest income quartiles being overrepresented. This is due in part to the fact that wealthier students are more inclined to attend college (Walpole, 2003). Developmental math students were more inclined to be in the lower two quartiles, had mothers with less education than the upper two quartiles, and tended to come from high schools where larger percentages of students were eligible for free or reduced lunch. Also, we fully expected that only one of the SES variables would remain in the final model; we were surprised to find three in the final model. Even though negative issues associated with SES can be difficult to overcome, developmental math instruction has clearly demonstrated success.

Next, the strong showing of locus of control in the regression model, in part, supports the findings of Hall and Ponton (2005) who reported that academically stronger students had a stronger sense of self-confidence. Though self-confidence and locus of control are different psychological constructs, they are closely related. In our examination of NELS: 88/2000 locus of control scores, developmental math students tended to have a more external locus of control, making them more apt to attribute life's successes and failures to concepts like luck; whereas those with stronger internal locus of control attribute success and failure to their own efforts. This observation is supported by the work of Grimes (1997).

Finally, this model hints at a framework for developmental education intervention. To change behavior, the developmental education programs must be directed at the determinants of behavior. According to the above findings, the determinants are raw math skill, the influences of poverty, and perceptions of behavioral control--together accounting for 24% in the variance of degree attainment.

Colleges, universities and state governments need to intervene early and work in tandem with school districts and communities to address the lack of readiness to undertake rigorous course work at the postsecondary level. Developmental math students may be affected and distracted by the issues of poverty long before they become developmental math students: financial problems, values and beliefs different from that of the postsecondary institution, weak or non-existent home and postsecondary support systems, and negative self-fulfilling prophecies are just a handful of the potential areas for intervention and future study.

Issues of poverty affect students' cultural perspectives, which form the foundations of their belief systems about the world and about themselves. In a study on the transition to college titled "Betraying the College Dream," researchers found that high school students, in general, had misunderstandings about what it takes to succeed in college, with low-income students and students of color having deep misunderstandings about college (Kirst & Venezia, 2004). For example, nearly all college-bound students, despite subgroup, tend to be more focused on gaining access to college, rather than on college success. This belief causes many high school students to take easier math classes in high school in order to get better grades; in contrast, the research indicates that even lower grades in rigorous classes lead to better chances of college success. As a rule, if the problem starts early, so should the solution. Therefore, developmental education programs should be partners in efforts to introduce algebra early to local secondary students, with 7th grade algebra after school projects or algebra summer camps.

Developmental education programs should integrate the best instructional practices with parallel material and attitudinal support systems for students and faculty. Developmental education programs need to cocoon students in a culture of success with significant peer and mentor support. Mentors can be powerful models of metacognitive problem solving. In terms of developmental education teachers, Vasquez (2004) described a similar program for instructors that included mentors, journaling, and help with pedagogical decision-making.

In many postsecondary institutions, once a student successfully completes intermediate algebra, he or she is deemed “ready” for college algebra. However, according to our findings, even with developmental education experiences, developmental education math students have a lower chance of success. An extended developmental education program could provide skill support for these students while they are taking college-level courses. Also, since time is an important factor in learning, typical semester/quarter systems may not always work. Developmental education researchers must experiment with new ideas such as formally intertwining developmental education math with college algebra or looping and having the same developmental math instructor travel with a cohort of students through the sequence of developmental education math courses and the first college level math course. Developmental education researchers may also want to study an intensive math semester, a kind of math boot camp that focuses on math skill, math related courses, self-concept and nothing else.

Conclusion

Developmental education is at the nexus of a complex problem. At the macro level, developmental education is effective; however, developmental education researchers and practitioners must work harder to tell the developmental education story. They must continue to develop a science for developmental education that informs practice. This science includes enriching the educational psychology that informs developmental education pedagogy. Finally, the NELS dataset took 14 years to complete; more developmental education researchers need to explore this rich resource.

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