PEER-REVIEWED ARTICLES

Predicting Preservice Mathematics Teachers' College Academic Achievement

Edwin P. Christmann, Slippery Rock University
Rich Busi, James Madison University
John L. Badgett, Slippery Rock University

Abstract

This study employed a multiple regression analysis to examine the relationship between academic aptitude and high school achievement factors to predict preservice mathematics teachers' college academic achievement. Specifically, an analysis of correlations and descriptive statistics was performed on predetermined academic factors of 67 undergraduate students enrolled as preservice mathematics teachers. In essence, a comparison of their SAT Verbal and SAT Mathematics scores, high school grade point averages, and college grade point averages disclosed significant relationships among all variables. Of special interest is that the mean high school grade point average of the preservice mathematics majors was a 3.63 (SD =.39), and the mean college GPA was 3.22 (SD =.56), which resulted in a correlation of $r = .53$, $n = .67$, $p < .01$.

Keywords: mathematics, SAT, GPA, preservice teachers, achievement

Introduction

Over the past several decades, education systems have been criticized for having ill-prepared teachers (Labaree, 2014; Stacy, 2005; Zimmerman, 2016) who lacked meaningful engagement with mathematics during their time as students (Attard, 2013). As colleges prepare students to become effective mathematics teachers, it seems that an examination of those factors that predict academic achievement for preservice mathematics teachers at the college-level are worthy of consideration. Recently, Westrick et al. (2020) extrapolated from 221,000 students across 169 four-year colleges and universities, that the SAT was essentially as effective as high school grades in predicting students' college performance and that these two measures, when combined, offer a more accurate understanding of student performance than does either measure when used alone.

The current study extends the College Board's validity research on the new SAT. Hence, this study attempts to determine whether SAT scores predict college academic achievement for preservice mathematics teachers better than do high school grades. The rationale for examining these factors stems from studies that show scholastic aptitude as a major predictor of success in the workforce (e.g. Bretz, 1989).

Although Lauren Gatti (2016) disagrees, it has nevertheless been substantiated that college achievement may indeed offer educational planners a means for predicting effective in-service teaching (James & Dumas, 1976). Research shows that students of teachers who have greater academic ability (e.g., as measured by GPAs, SAT scores, intelligence quotients, or even the universities they attended) perform better as classroom teachers than those taught by teachers with less academic abilities (Darling-Hammond, 2000). Specifically in mathematics, Sikora and Pitt (2017) found that success in secondary mathematics classes better prepares students for success in a university setting.

Based on this information, it seems reasonable to assume that the inclusion of higher achieving students in teacher education programs could offer the schools better teachers in the future. In concurrence with this assumption, an analysis of the factors that best predict the college-level achievement of preservice mathematics teachers should enhance the selection process of future in-service teachers, and later bolster mathematics achievement in the schools.

Literature Review

A review of literature suggests that there is a significantly positive relationship between students' tested abilities and their actual academic achievement (DeBerard et al., 2004). For example, SAT scores and high school grades are shown to predict the percentage of students who will graduate from college (Stumph & Stanley, 2002). Moreover, high school GPA is a better predictor of college achievement than SAT scores (Verbal and Mathematics scores combined) (DeBerard et al., 2004). Continuing, Akpotor & Egbule (2020) examined gender differences between senior secondary school adolescents in physics coursework. The paper, using a correlation matrix to examine the relationship in test scores and grades between males and females in physics, found that males do better in high school physics. However, there is little research regarding how SAT scores predict college achievement when examining Verbal and Mathematics SAT scores separately (Rhode & Thompson, 2007). Nevertheless, even though studies have investigated the relationship between factors that predict college GPA per se, there

is a paucity of studies that have investigated those factors that specifically predict the college GPAs of preservice mathematics teachers (Author, 2017).

Labaree (2004) concluded that until more is known about which factors can predict science preservice teacher achievement, the addition of more testing requirements for science teacher preparation could make "A simple induction process unnecessarily complicated." Ironically, although mathematics and science are areas of standardized testing emphasis, investigating which factors actually predict preservice teachers' college achievement is largely neglected (Author & Author, 1999). Additionally, this ongoing concern of educational stockholders and policymakers has not only resulted in radical decisions, but it has raised even more questions about the pool of America's teachers (Paine, 2011). For example, the Bush Administration declared that "American Education is in a recession," and this sentiment resounds in a cadre of books (Gross, 1999; Hirsch, 1996; Ravitch, 2000). Hence, expressed concerns that "anyone can be a teacher" is a blatant misconception by the public (Bushaw et al., 2011). Unfortunately, it seems that teaching is maintaining its lower status among the professions, while the brightest gravitate to higher status professions, e.g., medicine, law, and engineering.

In response to these criticisms, the No Child Left Behind Act (NCLB) of 2001 required each school district to "Ensure that all teachers hired after such day and teaching in a program supported with [NCLB] funds are highly qualified" (NCLB, 2008). The notion of highly qualified continues through the new Every Student Succeeds Act (ESSA). Regardless, even though educational planners emphasize the use of standardized tests to measure the academic achievement of preservice teachers, it follows that teacher preparation institutions should investigate standardized achievement test result patterns that actually predict preservice mathematics teachers' college achievement (Christmann & Badgett, 2001). As previously mentioned, a preservice teacher's undergraduate institution may be a useful indicator of potential teacher quality (Darling-Hammond, 2000; Goe & Sticklet, 2008). Although this is not always the case (Cavalluzzo, 2004), some studies disclose only a marginal relationship between a teacher's undergraduate school's emphases (i.e., an emphasis on High School GPA and SAT scores) and future academic achievement (Wayne & Youngs, 2003).

Ironically, current trends in higher education question the usefulness of the SAT, and recent scandals among prominent people have put into question the very use of the SAT. As

schools grapple with these realities, some educators, researchers, and psychologists have begun to question whether it is time to make a fundamental change in tests like the SAT. More broadly, they ask: If success in college is about 21st-century skills such as critical thinking, close reading, and collaboration, should gate-keeping tests such as the SAT continue to be used for making admissions decisions in higher education? Advocates of the SAT argue that learning more about where the SAT predicts achievement could help educational planners do a better job of measuring students' true capabilities (Toppo, 2020).

Optimistically, according to some reports, increases in teachers' academic ability could indicate that teacher quality may be improving (Hargraves, 2009). Along these lines, it has been found that teaching's occupational prestige and esteem are on the rise because more high-ability individuals are choosing teaching over other professions (Paine, 2011). Still, the National Council of Teacher Quality (NCTQ), along with other organizations and individuals, have raised questions about the quality of preservice teachers and the procedures for entry into teacher education programs. Thus, researchers are seeking answers to these questions (NCTQ, 2014).

We know from previous survey research that teachers' holding high expectations for students significantly increase the probability that those young people will go on to complete high school and college (Rubie-Davies, 2018). One indicator of teachers' expectations is their approach to grading: specifically, whether they subject students to more or less rigorous grading practices. Unfortunately, "grade inflation" is pervasive in U.S. high schools, as evidenced by rising GPAs, and this has been the case even as SAT scores and other measures of academic performance have held stable or fallen. Hence, a current problem is that a "good" grade is no longer a clear indicator of knowledge and skills (Gershenson, 2020). As a result, Gershenson (2020) found that students of all racial/ethnic groups learn more from teachers with high grading standards. Such standards tend to be higher in schools serving more advantaged students. Moreover, the impact of rigorous grading practices can improve student performance in subsequent math classes up to two years later.

In response to this research, the current study is a diagnostic effort to illuminate those factors that predict the overall college achievement of preservice mathematics teachers enrolled in a teacher certification program. Hopefully, the findings will result in a better understanding of which factors best predict the academic achievement of preservice mathematics teachers.

Methods

Overview

Analyses were performed on high school grade point averages and SAT Verbal, and SAT Mathematics scores for students enrolled as preservice mathematics teachers during their final year of undergraduate study. Both their college and high school GPAs were based on the standard grades of a 4-point scale.

Subjects

The subjects were 67 undergraduate students enrolled in a preservice mathematics teaching certification program at a comprehensive northeastern public university enrolling approximately 8100 students. These students had been admitted to the university and the teacher education program. The students' academic years varied, but all students who fit the mathematics teacher qualifier were recruited for the study, making this an accessible sample.

Research Design

The study employed a multiple regression analysis that examined the relationship between predictor variables and the criterion variable of the 67 preservice mathematics teachers. The criterion variable was college grade point average (GPA). Pearson product-moment correlations (r) were computed between each pair of variables. In addition, multiple correlations (R) and multiple regression results show relationships among all variables. The predictor variables used were (1) SAT Critical Reading Scores (Verbal), (2) SAT Quantitative Scores (Mathematics), and (3) High School GPA. The criterion variable used was the College GPA. The hypotheses for this study are as follows:

H_0: = High School GPAs, SAT Verbal Scores, SAT Mathematics Scores, have no significant relationship to College GPAs.

H1: = High School GPAs, SAT Verbal Scores, SAT Mathematics Scores, significantly affect College GPAs.

Results

Intercorrelations among College GPA (COLLGPA), High School GPA (HSGPA), SAT Math (SATMATH), and SAT Verbal (SATVERBAL) are shown in Table 1. The analysis measured the strength and directions of correlations among the College GPAs (COLLGPA), High School GPAs (HSGPA), SAT Math (SATMATH), and Sat Verbal (SATVERBAL) SCORES.

Table 1

Intercorrelational Coefficients Among the Variables Measured

		HSGPA	SATMATH	SATVERBAL	COLLGPA
HSGPA	Pearson Correlation	1	.432**	.248*	.529**
	Sig. (2-tailed)		.000	.043	.000
	N	67	67	67	67
SATMATH	Pearson Correlation	.432**	1	.538**	.263*
	Sig. (2-tailed)	.000		.000	.032
	N	67	67	67	67
SATVERBAL	Pearson Correlation	.248*	.538**	1	.256*
	Sig. (2-tailed)	.043	.000		.036
	N	67	67	67	67
COLLGPA	Pearson Correlation	.529**	.263*	.256*	1
	Sig. (2-tailed)	.000	.032	.036	
	N	67	67	67	67

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
HSGPA	67	2.5	4.2	3.6	.39
SATMATH	67	420.0	690.0	556.6	63.95
SATVERBAL	67	380.0	670.0	491.3	64.33
COLLGPA	67	1.9	4.0	3.9	.56
Valid N (listwise)	67				

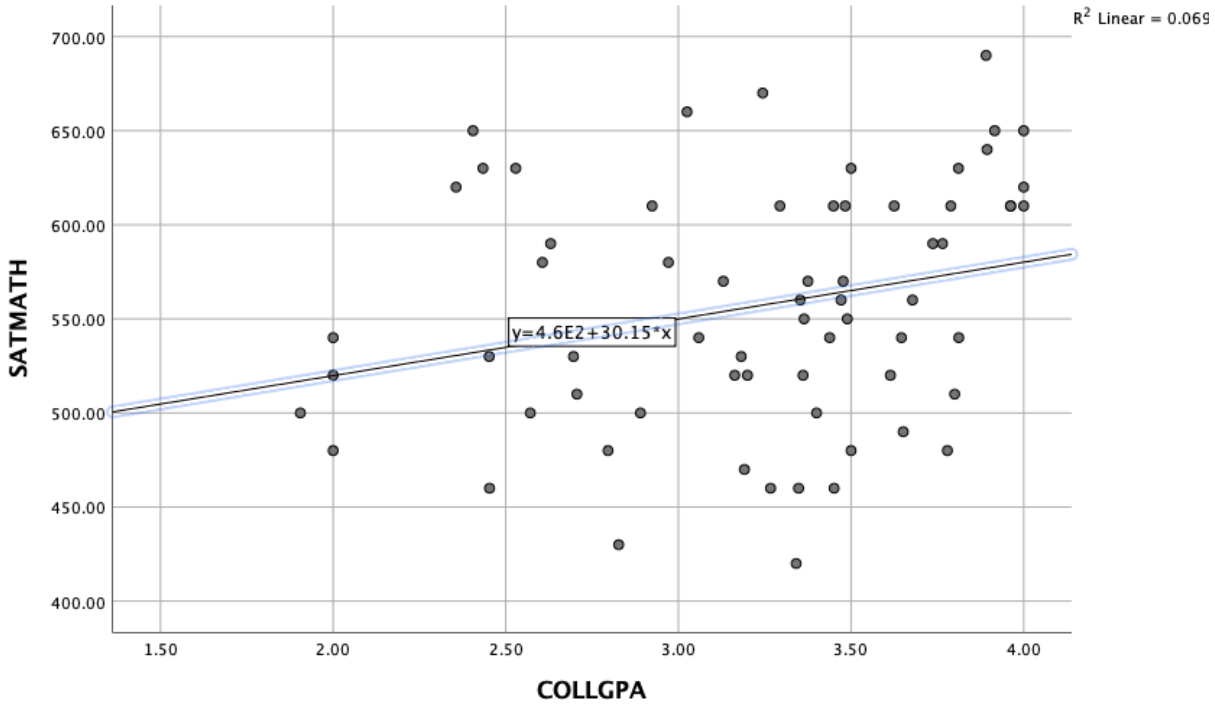
Table 2 shows the means and standard deviations for the variables. As reflected in Table 1, all of the correlations are significant and positive. Given that SAT Mathematics scores should predict a mathematics major's overall GPA, we examined the relationship between those variables. Figure 1 below shows the relationship between mathematics majors' mean SAT Mathematics score and their mean college GPA. The mean total SAT Mathematics score for mathematics majors was 556.72 (SD = 63.95), and the overall mean college GPA was 3.22 (SD = .56), thus resulting in a significant positive relationship, r = .263, adjusted r square = .055, n = 67, $p < .05$.

We also examined the relationship between high school GPA and college GPA. The mean high school GPA obtained by the preservice mathematics majors is a 3.63 (SD = .39), and the mean college GPA is 3.22 (SD = .56), thus resulting in a significant correlation, r = .53,

adjusted r square = .269, n= 67, p <.01, two tails (see Figure 2 below). This is of interest in that it exceeds the overall SAT-1 predictive validity coefficient of .44, as provided by Bridgeman et al. (2000). Hence, educational planners should give greater emphasis to high school GPA as a predictor of college achievement for preservice mathematics majors (Bridgeman et al., 2000).

Figure 1

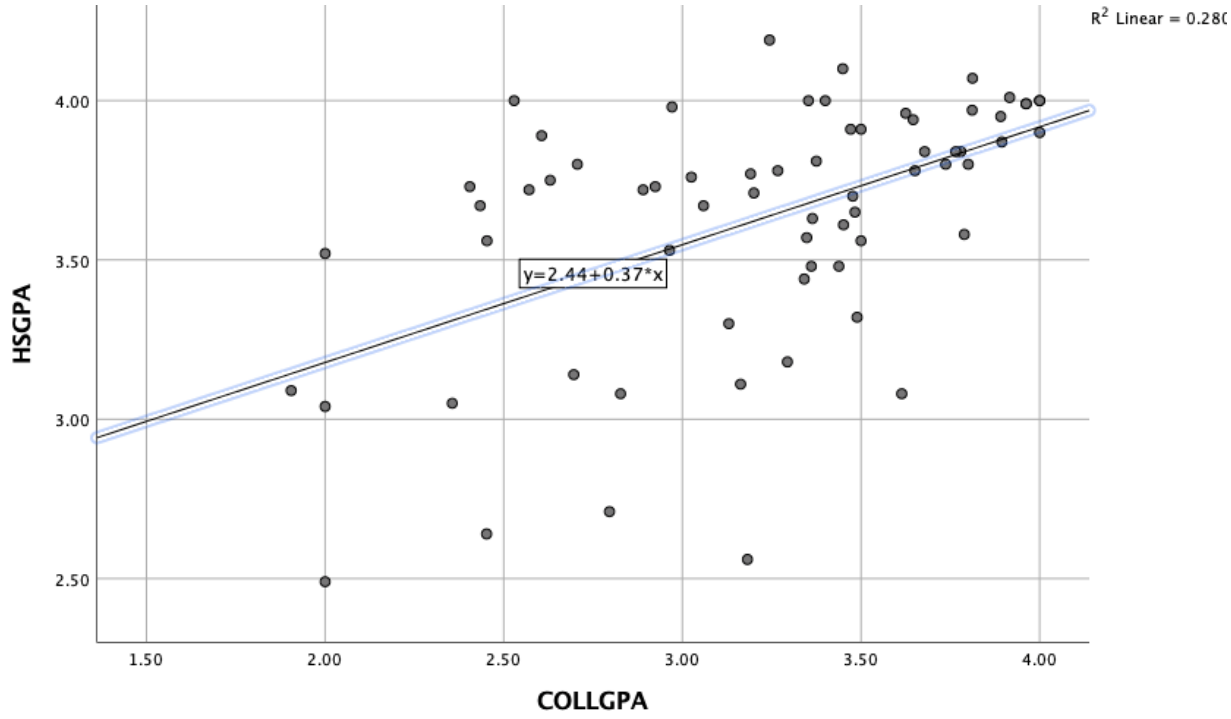
Scatterplot Relationship



Note. Shows preservice mathematics majors' SAT (math) scores and college GPAs.

Figure 2

Scatterplot Relationship

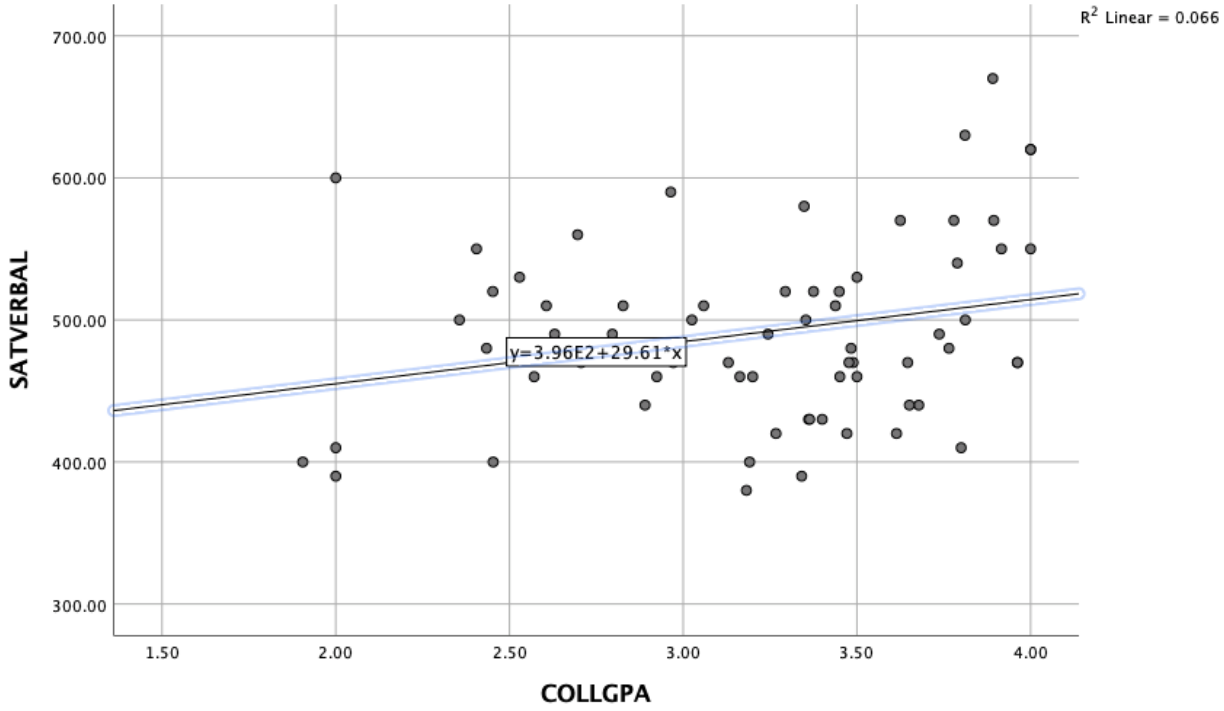


Note. Shows preservice mathematics majors' high school GPA and college GPA.

The mean SAT Verbal score obtained by the preservice mathematics majors is a 491.34 (SD = 64.34) and the mean college GPA is 3.22 (SD = .56), thus resulting in a significant correlation, r = .256, adjusted r square = .051, n = 67, p <.05, two tails (see Figure 3 below). This is of interest because it is very close to the mean SAT Mathematics correlation with College GPA. Perhaps mathematical reasoning is commensurate with certain aspects of grammar usage and editing skills. Hence, it seems plausible that those with higher intelligence score higher on both tests; especially when taking regression toward the mean into consideration. Therefore, this could explain why the highest correlation in the study was between the mean SAT Verbal and SAT Mathematics scores of the 67 preservice mathematics teachers, r = .538, n = 67, p <.01, two tails (no scatter plot displayed). Whatever the case, further research is needed to identify the best predictors of preservice mathematics teachers' academic achievement (e.g., problem solving, reasoning, critical thinking, etc.).

Figure 3

Scatterplot Relationship



Note. Shows preservice mathematics majors' SAT (verbal) scores and college GPA.

The standardized regression weights represent the amount of change in the dependent variable that is attributable to a single standard deviation unit's worth of change in the predictor variable (see Table 3 below). As a result of identifying these correlations, the best predictor of college GPA among preservice mathematics teachers is high school GPA.

Table 3

Results of Multiple Regression Analysis

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	.128	.661		.194	.847	-1.192	1.449
	HSGPA	.727	.168	.508	4.336	.000	.392	1.062
	SATMATH	.000	.001	-.038	-.281	.779	-.003	.002
	SATVERBAL	.001	.001	.151	1.201	.234	-.001	.003

Dependent variable: COLLGPA

Discussion

The present study explored the relationship among preservice mathematics teachers' SAT Verbal scores, SAT Mathematics scores, high school GPAs, and college GPAs. As a result, while there is a significant correlation among all variables, high school GPA appears to be the best predictor of college GPA within the tested sample of preservice mathematics teachers. This finding substantiates that of Thomas and Klymchuk (2012) which found that students sometimes have issues with notetaking, studying, and other academic skills that are amplified in the university setting. This predictive nature of high school GPA and college GPA may, in fact, be related to the auxiliary skills learned from successful high school grades that do not necessarily play a role in high stakes testing performance. Furthermore, as Skilling, Bobis, Martin, Anderson, and Way (2016) found, engagement in high school mathematics courses has large impacts on learners. Again, this lends support for high school GPA's having greater predictive power for college GPA than do more sterile high stakes tests, such as the SAT.

This is of interest in that state and federal policy makers continue to explore criteria for entrance into the teaching profession. Undoubtedly, the literature is legion with reports on the results of standardized tests and positive correlations with achievement results. However, success in high school is more often than not prerequisite to successful college achievement.

In agreement with this assertion, researchers have found that college GPA predicts teacher competency (James & Dumas, 1976). Additionally, a five-year-study of the relationship between standardized test data and grade-point average (GPA) among 1,800 teacher education students revealed that college GPA is useful in predicting effective teaching (Wilson & Robinson, 2012). Continuing, another report disclosed that GPA measures are better predictors of end-of-program performance measures than are standardized test results [26]. Hence, there is some question as to whether the National Observational Teaching Exam (NOTE) is a useful new instrument in measuring effective teaching. Regardless, understanding that GPAs relate to effective teaching, researchers may explore how the variables examined in this study relate to the results of the National Observational Teaching Exam in terms of concurrent and/or predictive validity (Martin-Raugh et al., 2016).

Limitations

The sample size (n = 67) of preservice mathematics students enrolled in the mathematics certification program is limited. This is particularly important in terms of the r-square values,

which are low primarily because of the small sample size. Moreover, the institution housing this study requires a minimum basic skill level for degree candidacy admission, e.g., 2.80 college GPA at 60 credits, and a minimum equivalent of 500 on each section of the SAT. Compounding the issue, it is widely acknowledged that teacher- generated grades at both the high school and collegiate levels have unspecified levels of reliability and content validity.

A second limitation is that the SAT serves as an assessment for those entering college. This particular study compared SAT scores to students in the last year of their program. Students who did not make so far in college may show a different relationship.

A final limitation is that this study explores the relationship between high school and overall college GPA —not the relationship between high school measures and education classes. The effect of general education, minor, and other courses may mask some of the variances between high school and teacher preparation measures.

Further Research

To this point, there is a limited understanding of the factors that predict preservice mathematics teachers' college GPAs. Hence, this study serves as a baseline for further research geared toward understanding the nature of predictive academic factors among preservice mathematics teachers, as well as other areas of preservice teaching, e.g., science, social studies, elementary education, etc. Understanding that SAT scores and high school GPAs are not the only factors that predict college academic performance, there is a need for more research on other possible predictors of college academic performance among preservice teachers, e.g., motivation, gender, study habits, high school class size, socioeconomic status, etc.

Given the emphasis of standardized tests in education, it is nevertheless important to consider affective factors that may predict effective teaching, e.g. personality traits, motivation measures, conscientiousness, etc. It is the opinion here that virtually any education department would do well to examine such relationships among its students' performances. Although the current study highlights the relationship between high school GPA and college GPA, the question remains as to whether there is solely a relationship between academic achievement and effective teaching. As a matter of caution, however, there are those who insist that good grades and high standardized test scores do not necessarily make for effective teaching. Undoubtedly, there are documented cases where poor teachers have high grades and high standardized test scores. However, that is not to insinuate that low grades predict successful teaching. Therefore,

it is our opinion that a reasonable starting point is first to consider pre-professionals' past academic achievement, i.e., High School GPAs. Undoubtedly, one of the best predictors of future achievement is past achievement, which appears to be a plausible starting point for entry into teacher training for prospective mathematics teachers.

Finally, it would be of interest to determine how well other standardized tests predict college GPA and/or Teaching Effectiveness, e.g. Preservice Academic Performance Assessment (PAPA), Praxis Core Academic Skills for Educators, ACT, National College Teaching Exam (NOTE), etc. Unquestionably, additional research is essential for determining the most effective policies for the maximum achievement of future teachers, which would definitely bolster future learning in America's schools.

Conclusion

Educational planners commonly use high school GPA and SAT results to predict future academic performance in higher education. In partial congruity, the results of this study reveal that of those factors examined, high school GPAs are the best predictor of the college GPAs of preservice mathematics teachers. Moreover, this present research offers new estimates of how other factors predict the college GPAs of preservice mathematics teachers. It also provides guidance on the potential benefits of using high school GPA as a covariate in educational research studies, particularly in studies of the undergraduate academic performance of preservice teachers. Consequently, it is anticipated that this research will deepen our understanding of the research tools at our disposal and thus contribute to enhancing the selectivity and rigor of preservice mathematics learning.

References

Attard, C. (2013). "If I had to pick any subject, it wouldn't be maths": Foundations for engagement with mathematics during the middle years. *Mathematics Education Research Journal*, 25, 569–587.

Akpotor, J., & Egbule, E. (2020). Gender difference in the Scholastic Achievement Test (SAT) among school adolescents. *World Journal of Education*, *10*(1), 97–101.

Brentz, R. D. (1989). College grade point average as a predictor of adult success: A meta-analytic review and some additional evidence. *Public Personnel Management, 18*(1).

Bridgeman, B., McCamley-Jenkins, L., & Ervin, L. (2000). Predictions of freshman grade point average from the Revised and Recentered SAT-I: Reasoning Test. *Unpublished research presented at the College Board*. http://research.collegeboard.org/sites/default/files/publications/2012/7/researchreport-2000-1-predictions-freshman-gpa-revised-recentered-sat-reasoning.pdf].

Bushaw, W.J., & Lopez, S. J. (2011). Betting on teachers: the 43rd annual PhiKappa/Gallup poll of the public's attitudes toward the public schools. *Phi Delta Kappan*, *93*(1), 8-26.

Cavalluzzo, L. C. (2004). Is national board certification an effective signal of teacher quality? Report No. IPR 11204. *The CAN Corporation*. http://www.cna.org/documents/CacaluzzoStudy.pdf

Christmann, E.P., & Badgett J.L. (1999/2000). A meta-analytic comparison between the academic achievement levels of students assessed with either traditional or alternative assessment techniques. *Louisiana Education Research Journal, 25*(1), 55-66.

Christmann, E.P., & Badgett J.L. (2001). A comparative analysis of the academic performances of elementary education preprofessionals, as disclosed by four methods of assessment. *Mid-Western Educational Researcher, 14*(2), 32-36.

Christmann, E.P., & Hicks, J.K. (2017). Predicting pre-service English teachers' college achievement. *Delta Journal of Education, 7*(1), 9-20.

Darling-Hammond, L. Teacher quality and student achievement: A review of state policy evidence. *Education Policy Analysis Archives, 8*(1), 1-45, 200.

DeBerard, M. S., Spielmans, G. I., & Julka, D. L. (2004). Predictors of academic achievement and retention among college freshmen: A longitudinal study. *College Student Journal*, *38*, 66-80.

Gatti, L. (2016). *Toward a framework of resources for learning to teach: Rethinking US teacher preparation*. Palgrave Macmillan.

Gershenson, S., Thomas B. Fordham Institute, & Thomas B. Fordham Foundation. (2020). Great expectations: The impact of rigorous grading practices on student achievement. In *Thomas B. Fordham Institute*. Thomas B. Fordham Institute.

Goe, L., & Sticklet, L. M. (2008, March). Teacher quality and student achievement: making the most of recent research. *Educational Testing Service*. http://files.eric.ed.gov/fulltext/ED520769.pdf

Gross, M. L. (1999). *The conspiracy of ignorance: the failure of American public schools*. Harper Collins.

Hargreaves, L. (2009). The status and prestige of teachers and teaching. In Saha L.J., & Dworking A.G. (Eds), *International Handbook of Research on Teachers and Teaching* (pp. 217-229). Springer.

Hirsch, E. D. (1996). *The schools we need and why we don't have them*. Doubleday.

James, T. L., & Dumas, W. (1976). College GPA as a predictor of teacher competency: a new look at an old question. *Journal of Experimental Education*, 44(4), 40-43.

Labaree, D. F. (2004). *The trouble with Ed schools*. Yale University Press.

Labaree, D. F. (2014). Let's measure what no one teaches: PISA, NCLB, and the shrinking aims of Education. *Teachers College Record*, *116*(9), 1-14.

National Council of Teacher Quality (2014). *Training our future teachers: Easy A's and what's behind them*. http://www.nctw.org/dmsView/EasyAs.

No Child Left Behind Act of 2001: Qualifications for Teachers and Professionals, 20 U.S.C. § 6319 (2008).

Paine, S. L. (2011). *What the U.S. can learn from the world's most successful education reform efforts*. McGraw-Hill.

Ravitch, D. (2000). *Left back: A century of failed school reforms*. Simon and Schuster.

Rhode, T. E., & Thompson, L.A. Predicting academic achievement with cognitive ability. *Intelligence*, *35*(1), 83-92.

Rubie-Davies, C.M. (2018). *Teacher expectations in education*. Routledge.

Sikora, J. & Pitt, D. G. W. (2017). Does advanced mathematics help students enter university more than basic mathematics? Gender and returns to year 12 mathematics in Australia. *Mathematics Education Research Journal*, *31,* 197–218.

Skilling, K., Bobis, J., Martin, A. J., Anderson, J., & Way, J. (2016). What secondary teachers think and do about student engagement in mathematics. *Mathematics Education Research Journal*, *28,* 545–566.

Stacey, K. (2005). The place of problem solving in contemporary mathematics curriculum documents. *Journal of Mathematical Behavior*, *24*(3), 341–350.

Stumpf, H., & Stanley, J. C. (2002). Group data on high school grade point averages and scores on academic aptitude tests as predictors of institutional graduation rates. *Educational and Psychological Measurement, 62*(6), 1042-1052.

Thomas, M. O. J., & Klymchuk, S. (2012). The school-tertiary interface in mathematics: Teaching style and assessment practice. *Mathematics Education Research Journal*, *24*(3), 283–300.

Toppo, G. (2020). Support builds for making the SAT untimed for everyone: A possible solution to the "Gaming the System" problem. *Education Next*, *20*(1), 42–49.

Wayne, A. J., & Youngs, P. (2003). Teacher characteristics and student achievement gains: A review. *Review of Educational Research*, *73*(1), 89-122.

Westrick, P. A., Marini, J. P., Shmueli, D., Young, L., Shaw, E. J., Ng, H., & College Board. (2020). Validity of SAT® for predicting first-semester, domain-specific grades. In *College Board*. College Board.

Wilson, B., & Robinson, V. (2012). Predicting teacher performance: Proceed with caution. *Journal of Assessment and Accountability in Educator Preparation*, *2*(1), 58-61.

Zimmermann, B. (2016). Improving of mathematical problem-solving: Some new ideas from old resources. In P. Felmer, E. Pehkonen, & J. Kilpatrick (Eds.), *Posing and solving mathematical problems* (pp. 83–108). Springer.

Author Biographies

Dr. Edwin P. Christmann is a professor and chairman in the Secondary Education/Foundations of Education Department at Slippery Rock University.

Dr. Rich Busi is an assistant professor of mathematics education in the Department of Mathematics and Statistics at James Madison University.

Dr. John L. Badgett is a professor emeritus from the Secondary Education/Foundations of Education Department at Slippery Rock University.