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Impact of the Siena College Tech Valley Scholars Program on Student Outcomes

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Siena College

Abstract

The Tech Valley Scholars (TVS) program included 38 students who joined this program over the course of three academic years, from 2009 to 2012. These students comprise the experimental group for this study to determine if participating in the NSF-funded Tech Valley Scholars program improved academic outcomes. The experimental group was compared to a randomly selected control group of STEM majors, as well as a matched set. The TVS group had significantly higher persistence rates and final cumulative GPAs than both control groups. Additionally the data gathered provides evidence that unmet financial need is an important non-retention risk factor that, when mitigated, results in enhanced academic success. Recommendations for effective and efficient allocation of scholarship funds are given and future statistical studies are recommended.

Siena College is a liberal arts college with a strong School of Science. The college is in a region of upstate NY designated as Tech Valley for the recent growth in nanotech and other high tech research and industries. In recent years, over $3M in funding has been obtained from NSF for programs and research in STEM education at Siena College. The NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) grant, obtained in 2009, was used to create a program we call Tech Valley Scholars (TVS). Per the NSF S-STEM guidelines, the TVS program's goal is to increase the number and quality of students graduating and entering the STEM workforce. In particular, we award scholarships based on unmet financial need and high level of academic promise. In addition to scholarships, a one-credit career preparation seminar, cohort activities, and extra mentoring are provided. The purpose of this paper is to present the results of statistical analyses on the persistence and performance of TVS students. Analyses investigated the retention rates and GPA for the TVS cohort compared to matched and unmatched control groups.

Rationale

The U.S. must increase the number of majors in STEM fields and strengthen the science and technology workforce in order to lead the global economy. The February 2012 report by the President's Council of Advisors on Science and Technology (PCAST) set a goal of producing one million additional college graduates with STEM degrees over the next decade (Holdren & Lander, 2012). However, the PCAST report states that fewer than 40% of students who enter college intending to major in a STEM field actually complete a STEM degree. Low completion rates among STEM majors may be related to the difficulty colleges and universities have in recruiting and retaining sufficient numbers of STEM students. Specific reasons for the low completion rate among STEM majors include uninspiring introductory courses, an unwelcoming atmosphere in STEM departments, and lack of support/mentoring systems (Augustine, 2007; Holdren & Lander, 2012). These factors are complicated in the case of STEM majors, such as computer science, that are not readily taught in high school programs (Bowling, Bullen, Doyle, & Filaseta, 2013; Dahlberg, Barnes, Rorrer, Powell, & Cairco, 2008), and have even greater impact on at-risk students (Barlow & Villarejo, 2004; Herrera & Hurtado, 2011; IHEP, 2007; Landry, 2003). On the positive side, recent investigations suggest there are strong benefits of cohort programs, community building, and undergraduate research for recruiting and retaining STEM students (ACS, 2008; Angrist, Lang, & Oreopoulos, 2009; APS, 2014; CUR, 2007, 2014; Hathaway, Nagda, & Gregerman, 2002; Hodge, Pasquesi, Hirsh, & LaPore, 2007; Hunter, Laursen, & Seymour, 2007; Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998; Rauckhorst, Czaia, & Baxter Magolda, 2001; Russell, Hancock, & McCullough, 2007; Seymour, Hunter, Laursen, & Deantoni, 2004; Whalen & Shelley, 2010).

Details about the Siena TVS S-STEM Program

Since its inception in 2009, the Siena College Tech Valley Scholars (TVS) program will have impacted over 38 undergraduate Tech Valley Scholars in Biochemistry, Chemistry, Computer Science, Mathematics, and Physics, with a STEM graduation rate of greater than 90%. TVS students take part in summer research at Siena and at top NSF Research Experiences for Undergraduate (REU) programs. TVS students have an excellent record of going on to strong graduate schools and professional programs. TVS not only promotes a strong cohort atmosphere but also an important peer mentoring aspect (Gafney, 2005; Gottesman & Hoskins, 2013). Early exposure to faculty and upperclassmen from all disciplines has shown promise in broadening students' scientific curiosity (Barlow & Villarejo, 2004; Bauer & Bennett, 2003; Campbell & Skoog, 2004; Lopatto, 2004). By introducing the incoming TVS cohort students to successful STEM students, incoming students gain exposure to a group of students in a program that has proven to increase both retention and GPA relative to the general population of STEM majors (Gottesman & Hoskins, 2013).

Another characteristic of the TVS program that has a positive impact on student retention is the career exploration seminar. Research suggests that activities exposing students to career options increases retention (Herrera & Hurtado, 2011). Over the years, student assessments show enthusiasm for many aspects of the TVS career seminar, including 1) information gathering about career paths and the best match with STEM majors, 2) interview and communication skills, 3) discussions concerning REU and other applications to external programs, 4) summer scholarship proposals and internship ideas, and 5) curriculum vitae preparation seminars conducted by the Career Center. Additionally, STEM professionals from academia and industry speak with TVS students. Guest speakers from the following local and national organizations have presented: General Electric, Knolls Atomic Power Labs, Biogen, SUNY Polytechnic Institute, and RPI Alternative Energy Research.

The Siena TVS program has been a significant co-contributor to the recent growth in STEM majors at Siena. The Physics Department, which has a high number of TVS students, experienced tremendous growth in the number of physics majors, from an average of 16 prior to the S-STEM grant to the current average of about 60 physics majors. Now that TVS students are graduating, we have impressive data on what they are currently doing, including pursuing graduate studies at institutions including Stanford University, University of Washington,

SUNY Polytechnic Institute, Dartmouth College, University of Colorado, and MIT.

Over the five-year period of our Tech Valley Scholars S-STEM grant, 38 different students have participated in our program. Of those, 47% are female and 53% are male, and the average GPA over the grant period is 3.59. The majors of our S-STEM students are as follows: 16% Biochemistry, 12% Chemistry, 16% Computer Science, 19% Mathematics, and 35% Physics. About 97% of our students who joined Tech Valley Scholars have graduated in four years, and they tend to go on to STEM career paths in the following proportions: 50% enter Ph.D. programs, 36% enter Master's programs with the possibility of Ph.D. programs later, and 14% enter the STEM workforce directly from their undergraduate programs.

Table 1 presents the results for the students in our program over the grant period and the average amounts of the scholarship awards. The total amount awarded for S-STEM scholarships from 2009-2014 was $518,188. Following the initial year of funding, the increase in average award amounts in the latter three years reflects declining students' family finances.

Assessment of student satisfaction via end of semester surveys (data not shown) suggests not only high levels of enthusiasm for the career seminar but also high overall satisfaction with participation in the program. In particular, graduating students report that the program exposed them to the breadth of STEM careers possible and helped them to direct their interests towards specific career paths. The following are typical examples of TVS senior student responses to the survey question about their career paths as a consequence of the TVS program: "I am now graduating with a B.S. in Physics and Math and going on to MIT to pursue my Ph.D. in Planetary Science. My decision to continue on for my Ph.D. was largely influenced by my participation in the seminar." "Due to these seminars I gained a better understanding of the scientific industry. Because of this, I pursued jobs in both Computer Science and Mathematics and was lucky enough to receive multiple job offers!"

Study Objectives and Research Questions

The objectives of the current study are to explore the validity of the qualitative data via results of quantitative analyses to test the hypothesis that participation in the TVS program positively impacts student outcomes, thereby making a positive difference in students' academic experiences and career paths.

Four research questions were addressed:

1. What demographic and background variables are associated with risk of non-retention and lower cumulative GPA for students in the School of Science at Siena College? (Identification of these variables could help to determine potential confounders in our analysis of TVS outcomes.)
2. Do students in TVS have a higher retention and graduation rate than their peers who were not in TVS?
3. Do students in TVS have higher academic performance than their non-TVS peers?
4. Is the allocation of scholarship funds being done in the best way to accomplish the goals of the NSF S-STEM program?

TVS students and controls were compared on two primary outcome variables: persistence (defined as either graduation or retention to senior year) and final cumulative GPA. Please note that while it is not possible at this time to track all TVS participants to graduation (since we have included recent cohorts who are still enrolled), retention to senior year is a close proxy for graduation at Siena College as graduation rates for students who reach their fourth year at the college are very high. For example, out of 315 full-time, degree-seeking students in the School of Science who were classified as seniors in the fall of 2013, 308 or 97.8% have graduated from Siena.

Methods

Preliminary Risk Analysis

A preliminary analysis was performed to establish risk factors for non-persistence and low GPA among incoming students who would have been eligible to participate in the TVS program. This analysis was conducted to identify potential confounding variables that might influence the relationship between participation in the TVS program and the academic outcomes of interest.

Specifically, the cohort for this preliminary risk analysis consisted of new and transfer students who entered Siena College between the fall 2008 and fall 2011 terms and who matriculated with a declared major in a STEM field (excluding biology) or with an undeclared science major. There were 464 students who met these criteria for inclusion in the preliminary risk analysis, including 35 students who eventually participated in the TVS program.

Persistence

On the basis of previous unpublished research conducted at Siena College, a set of potential risk factors for non-persistence was identified. Non-persistence was defined as leaving Siena College prior to graduation. We identified eight potential risk factors for non-persistence. These risk factors are: having transferred from another college, matriculating without a declared major, being male, being a member of an underrepresented racial or ethnic minority group, living off campus, having unmet financial need (based on information provided on the FAFSA form), being a Pell grant recipient, or having low "aid grade" (a measure of academic preparation, derived primarily from high school GPA and SAT/ACT test scores).

For each risk factor, a chi-square test was performed to determine if there were significant differences in persistence rates across the levels of the risk factor for the cohort of students (N=464) included in the preliminary risk analysis. Next, logistic regression was used to determine the unique contributions of each of these risk factors, taking into account the presence of the other risk factors. The dependent variable was persistence: students who left Siena (N=112) were coded 1, while students who graduated or who were still enrolled in the fall 2014 term (N=352) were coded 0. The predictor variables were the risk factors listed above, coded dichotomously as 1 or 0, with a value of 1 corresponding to the presumptive risk value. Aid grade and unmet need are continuous variables, but were coded dichotomously at a threshold value based on previous research at Siena College. The analysis was conducted using the logistic regression procedure in SPSS with a forward method of variable selection.

Cumulative GPA

A similar preliminary analysis was conducted to examine the potential effect of these same risk factors on students' final cumulative GPA. T-tests were conducted to determine if there were significant differences across levels of the risk factors. A one-way analysis of variance was used to test for differences across four successive levels of unmet need (defined in terms of $5000 increments), using the general linear model procedure in SPSS with post-hoc comparisons. Next, multiple linear regression was used to determine the unique contribution of each of the predictor variables. The outcome variable was final cumulative Siena GPA; the predictor variables were the risk factors identified above, with the exception that aid grade was coded continuously. This analysis was conducted using the linear regression procedure in SPSS with a stepwise method of variable selection.

Selection of TVS Participants

The experimental group for this study comprised 38 students who entered the TVS program from 2009-2010 through 2011-12. As previously noted, students must apply for admission to the TVS program and meet certain

Data on the current Tech Valley Scholars program. Note that many students participated for multiple years, so the sum of the numbers in row two is 119 student-years.

Academic Year	2009-10	2010-11	2011-12	2012-13	2013-14
Number Participating	8	29	25	36	21
Total Amount Awarded	$54,540	$93,240	$85,166	$159,536	$125,706
Average Amount Awarded	$6,818	$3,215	$3,407	$4,440	$5,986

Table 1

Characteristics of TVS Students.			
	TVS students	**Matched controls**	**Random controls**
Gender			
Female	18	18	45
Male	20	20	55
Ethnicity			
Minority	2	2	2
White/Asian	36	36	98
Year at Siena			
1st year	18	18	32
2nd year	12	12	29
3rd year	5	5	12
4th year	3	3	22
5th/6th year	0	0	5
Student type			
New	34	35	93
Transfer	1	1	1
Other	3	2	6
Major			
Biochemistry	6	8	17
Chemistry	1	2	14
Computer Science	6	6	8
Math	6	6	14
Physics	9	7	9
Undeclared	10	9	38
Housing			
Commuter	7	6	16
On-campus	31	32	84
Financial aid			
Applied	35	36	92
Did not apply	3	2	8
Pell status			
Recipient	9	9	20
Non-recipient	29	29	80
Aid grade (average)	68.0	66.7	54.7

Table 2

criteria for acceptance. Demographic and background characteristics of the TVS students are shown in Table 2.

Random control group

The TVS group was compared to two different control groups (see Table 2). The first control group consisted of 100 randomly selected STEM students who did not participate in the TVS program. The random control group were selected from students who had a declared major in a STEM field or were undeclared science majors and matriculated into Siena as new or transfer students between fall 2008 and fall 2011.

Matched control group

While the first control group consisted of students who were randomly selected, it is possible that these students were in some way at higher risk than the TVS students. Thus, the better outcomes of the TVS students

could be due to confounding factors rather than from their participation in the TVS program *per se.*

To control for potential confounds, a second control group was defined by matching each of the TVS participants to a non-participating student on the basis of multiple criteria to ensure closer comparability between the two groups. Matching criteria were selected in part to minimize the potential influence of confounding variables that are known on the basis of previous research to be potential risk factors (Allard, 2013). The majority of TVS students could be matched to a control on all of the below criteria. However, for a minority of TVS students the matching was incomplete on one or more variables; the numbers in parentheses indicate the number of exact matches for that criterion. The following criteria were used to select the matching controls:

- Major: students were matched on the basis of whether or not they had a declared major. Specifically, TVS students with an undeclared science major were matched to control students with an undeclared science major; TVS students with a declared STEM major were matched to control students with a declared STEM major. Within the STEM majors, no effort was made to match students more specifically. Thus, for example, a biochemistry major could be matched to a physics major. (37/38 matches)
- Year in college: students were matched on the basis of their year in college (i.e. first year, second year, etc.). So, for example, a student who entered the TVS program in their second year would be matched to a non-TVS student in their second year. (38/38 matches)
- Matriculation status: students were matched on the basis of their matriculation status (i.e. new or transfer student). (36/38 matches)
- Gender: students were matched on the basis of their gender. (38/38 matches)
- Minority status: students were matched on the basis of their minority status (i.e. minority vs. non-minority). Asian students, multiracial students, and students of unknown ethnicity were classified as non-minority. (38/38 matches)
- Aid grade: students were matched on the basis of aid

grade, which is a measure of academic preparation derived primarily from SAT scores and high school GPA. Aid grade ranges from 10 to 75. Students were matched within a range of +/- 5 points on the aid grade scale. (36/38 matches)

- Living arrangements: students were matched based on whether they lived on campus or were commuters. (37/38 matches)
- Financial aid status: students were matched based on whether they applied for financial aid. (37/38 matches)
- Pell grant status: students were matched based on whether they were Pell grant recipients. (38/38 matches)

Previous unpublished research at Siena College has found that a significant risk factor for non-persistence is the amount of unmet financial need that a student has. It was not possible to match students closely on the level of unmet need, given the very broad range of values for this variable. However, a post-hoc comparison of unmet need was performed for the two groups. Two types of unmet need were used: students' unadjusted unmet need at the time of matriculation (this measure does not take into account loan amounts), and students' adjusted unmet need at the time of their application to the TVS program (or comparable term for the controls). Adjusted unmet need adds in student loan amounts. A comparison of unadjusted need between the two groups showed no significant difference, while a comparison of adjusted unmet need showed that the TVS group actually had a significantly higher average amount of unmet need. Thus, differences in level of unmet need would not explain any better outcomes for the TVS group.

One potential problem with the GPA comparison is that the TVS group had to have a minimum cumulative GPA of 3.0 for admission to the TVS program while no such restriction was placed on the matched controls. It might be possible, of course, to match the two groups on cumulative GPA, but this would be problematic for at least two reasons. First, cumulative GPA is a moving target, and since there is no set entry time for participation in the TVS program, there are multiple possible entry points (with varying GPA values) for any student who might be interested in the program. Second, the possibility of participating in the program could serve as a motivating factor for some students. In other words, even before applying to the TVS program, a student might be motivated to raise their GPA to the admission threshold. This option would have been available for all students in the pool of potential TVS participants.

Analysis of the data showed that 32 of 38 of the matched controls had a final cumulative GPA of over 3.0, meaning that they would have been eligible for the TVS program at some point in their academic career. Of the remaining six control students, four had a final cumulative GPA of at least 2.8, suggesting that with a little "push" these

students could have been eligible for the TVS program. Of the remaining two controls, one had a first-term GPA of over 3.0 so that students would have been TVS-eligible at that point. It does not appear, therefore, that the GPA threshold for the TVS group significantly impacted the results of the study. Nevertheless, an additional analysis was conducted to provide some insight into whether participation in the TVS program is associated with a real increase in GPA by comparing the change in GPA from students' first term to their final cumulative GPA. To this end, a matched-pairs t-test was performed comparing the change in GPA for the TVS and matched control groups.

Comparison of Outcomes for TVS and Control Groups

Persistence rates for the TVS group were compared to persistence rates for each of the two control groups, using a chi-square test of proportions. However, it is possible that any differences found between the two groups in this univariate analysis could be attributed to confounding factors (i.e. factors other than participation in the TVS program). To test this hypothesis, an additional analysis was performed using logistic regression. The dependent variable was persistence (i.e. graduation or retention to senior year), coded dichotomously as 1 for non-persisting students and 0 for persisting students. The predictor variables were drawn from the preliminary risk analysis (see above), with the addition that TVS status was also included as a predictor variable (1=non-TVS, 0=TVS). The purpose of this multivariate analysis was to determine if an effect of TVS participation remains even when other risk factors for non-persistence are included in the model.

Differences in cumulative GPA between the TVS group and each of the control groups were compared using a t-test. However, once again it is possible that any differences found between the two groups in this univariate analysis could be attributed to confounding factors. To test this hypothesis, an additional analysis was performed using multiple linear regression. The dependent variable was final cumulative GPA. The predictor variables were drawn from preliminary risk analysis (see above), with the addition that TVS status was also included as an additional predictor variable (1=non-TVS, 0=TVS).

Results

Preliminary Analysis of Risk Factors

Persistence

A preliminary analysis was conducted to determine risk factors for non-persistence among incoming students in the School of Science who would have been eligible to participate in the TVS program (N=464). Persistence was defined as either graduating from Siena College or being retained to their senior year. This preliminary analysis was important to determine potential confounding

Persistence rates and cumulative GPA categorized by risk factors.

	Count	Graduation / Persistence Rate	Graduation / Persistence Significance	GPA / Performance GPA	GPA / Performance Significance
Gender					
Female	224	79.9%		3.14	
Male	240	72.1%	$\chi^2(1)=3.88, p<0.05$	2.96	$t=3.17, df=455, p<0.002$
Ethnicity					
Non-minority	428	76.2%		3.08	
Minority	36	72.2%	$\chi^2(1)=0.28$, n.s.	2.58	$t=4.58, df=455, p<0.001$
Student type					
New	447	76.3%		3.05	
Transfer	17	64.7%	$\chi^2(1)=1.20$, n.s.	2.90	$t=0.93, df=455$, n.s.
Residence					
On-campus	402	77.6%		3.06	
Commuter	62	64.5%	$\chi^2(1)=5.03, p<0.03$	2.95	$t=1.22, df=455$, n.s.
Major					
Declared	305	78.0%		3.03	
Undeclared	159	71.7%	$\chi^2(1)=2.29$, n.s.	3.07	$t=0.65, df=455$, n.s.
Aid grade					
40 or more	371	79.5%		3.16	
35 or less	93	61.3%	$\chi^2(1)=13.49, p<0.001$	2.60	$t=8.11, df=455, p<0.001$
Pell status					
Non-Pell	363	79.3%		3.11	
Pell recipient	101	63.4%	$\chi^2(1)=11.01, p<0.001$	2.82	$t=4.17, df=455, p<0.001$
Unmet need					
<5K	352	82.4%		3.07	
5-10K	59	71.2%		3.16	
10-15K	29	58.6%		2.96	
15K+	24	12.5%	$\chi^2(3)=66.21, p<0.001$	2.38	$F(3,453)=8.85, p<0.001$
Total	464	75.9%		3.05	

variables that could affect the relationship between TVS participation and academic outcomes.

The persistence rates for at-risk subgroups are summarized in Table 3. For each variable (e.g. gender or ethnicity), a chi-square test was performed to determine if the difference in persistence rates across levels of that variable was statistically significant. Results indicated that males, commuter students, students with low aid grade (a measure of academic preparation), Pell grant recipients, and students with high unmet need had significantly lower persistence rates. Transfer students also had a relatively low persistence rate, but the difference was not statistically significant, as the number of transfer students was quite small.

Next, logistic regression was used to determine the unique contributions of these risk factors. The dependent variable was persistence: students who left Siena (N=112) were coded 1, while students who graduated or who were still enrolled in the fall 2014 term (N=352) were coded 0. The predictor variables were the risk factors listed in Table 3. The analysis was conducted using the logistic regression procedure in SPSS with a forward method of variable selection.

The overall model was statistically significant, $\chi^2(3) = 58.4, p<0.001$. Table 4 shows the final model with the

three predictor variables that were statistically significant. The table also shows the odds ratio associated with each of these predictor variables. Unmet financial need greater than $10,000 was the strongest predictor of non-persistence (Odds Ratio = 7.45), followed by low aid grade (Odds Ratio = 2.58) and being male (Odds Ratio = 1.73). The other risk factors dropped out of the logistic regression model. These results suggest that students with unmet financial need > $10K have a non-retention rate approximately 7 times higher than students with lower unmet need; students with low aid grade have a non-retention rate approximately 2.5 times higher than students with high aid grade; and students who are male have a non-retention rate approximately 1.7 times higher than female students, assuming the other variables in the model are held constant.

Cumulative GPA

The second part of the preliminary analysis examined potential risk factors that might be correlated with students' final cumulative GPA. T-tests were conducted to determine if these risk factors were associated with lower GPA. Table 3 (far right column) summarizes the results of these univariate analyses. Male students, minority students, students with low aid grade, and Pell grant

Logistic regression model for persistence

	B	S.E.	Wald	df	Sig.	Exp(B)
Male	0.55	0.24	5.10	1	0.024	1.73
Low aid grade	0.95	0.27	12.08	1	0.001	2.58
Unmet need > $10K	2.01	0.32	39.64	1	0.000	7.45
Constant	-2.01	0.21	89.17	1	0.000	0.13

Table 4

recipients all had a significantly lower final GPA than the respective comparison groups.

A one-way analysis of variance was used to test for differences across the four levels of unmet need noted in Table 3, using the general linear model procedure in SPSS with post-hoc comparisons. Students with very high unmet need (greater than $15,000) had a significantly lower final GPA than all three of the other levels of unmet need. However, there were no significant differences across the three lower levels of unmet need; in fact, students with a moderate level of unmet need ($5,000 to $10,000) had a higher final GPA than students in the lowest unmet need category.

Next, multiple linear regression was used to determine the unique contribution of the predictor variables to final GPA. The outcome variable was final cumulative Siena GPA; the predictor variables were the same risk factors as those identified above with the exception that aid grade was coded continuously. This analysis was conducted using the linear regression procedure in SPSS with a stepwise method of variable selection. The overall regression model was statistically significant, $F(4, 448) = 43.4$, $p<0.001$. Table 5 shows the final model with the four predictor variables that were statistically significant.

Results indicated that the strongest predictor of cumulative GPA was aid grade: students with a higher aid grade when they entered Siena had on average a higher cumulative GPA at the end of their Siena career with the linear regression results suggesting that each unit increase in aid grade predicts GPA increase of 0.01, assuming the other variables in the model are held constant. Other statistically significant predictors of cumulative GPA were students with an unmet financial need greater than $10,000, male students, and minority students, all of which predicted lower average GPA.

Results for the Random Control Group

Persistence

For the TVS group, 37 out of 38 students (97.4%) either graduated or were still enrolled as of August 2014. For the random control group, 84 out of 100 students (84%) either graduated or were still enrolled as of August 2014. The difference in graduation / retention rate was statistically significant, $\chi^2(1) = 4.56$, $p<0.05$.

In order to examine the effects of TVS participation on persistence while controlling for possible confounding factors, a logistic regression analysis was performed with persistence as the dependent variable (coded 1 for

non-persistence and 0 for persistence; data not shown). The predictor variables were those used in the preliminary risk analysis (see above), with the addition that TVS status was also included as a predictor variable (1=non-TVS, 0=TVS). The overall logistic regression model was statistically significant, $\chi^2(1) = 16.4$, $p<0.001$. All predictor variables dropped out of the final model except unmet financial need, which remained as a very strong predictor with an odds ratio of 21.5.

Cumulative GPA

Turning to the second outcome variable, final cumulative GPA, the TVS group had an average GPA of 3.61, compared to 3.04 for the random control group. This difference was also statistically significant, $t(134) = 5.19$, $p<0.001$ (data not shown).

In order to examine the effects of TVS participation on GPA while controlling for possible confounding factors, a multiple regression analysis was performed with final cumulative GPA as the dependent variable. The predictor variables were those used in the preliminary risk analysis (see above), with the addition that TVS status was also included as a predictor variable (1=non-TVS, 0=TVS). The overall regression model was statistically significant, $F(4, 130) = 19.8$, $p<0.001$. Table 6 shows the final model with the four-predictor variables that were statistically significant. The strongest predictor of final GPA was aid grade, which is not surprising since aid grade is a measure of academic preparation. However, TVS status also remained in the model as a significant predictor of final GPA, as did unmet need and being male.

Results for the Matched Control Group

Persistence

37 out of 38 of the TVS students (97.4%) either graduated or were still enrolled as of August 2014, compared to 34 out of 38 of the matched controls (89.5%). However, the difference was not statistically significant, $\chi^2(1,N=76) = 1.93$, $p=0.165$. Also, it should be noted that 36 of 38 TVS students remained in a STEM major, compared to 30 of 38 non-TVS students; this difference was statistically significant, $\chi^2(1,N=76) = 4.15$, $p<0.05$.

Cumulative GPA

The TVS group had an average final Siena cumulative GPA of 3.61, compared to 3.30 for the matched control group. This difference was statistically significant using a paired samples t-test, $t(37) = 3.62$, $p<0.001$ (data not shown). However, as noted earlier the TVS group had a somewhat higher GPA to begin with. Therefore an additional analysis was conducted to compare the change in GPA from students' first term to their final cumulative GPA, to provide some further insight into whether participation in the TVS program is associated with an increase in GPA. To this end, a matched-pairs t-test was performed comparing the change in GPA for the TVS and

Multiple regression model of cumulative GPA

	Beta	Std. Error	Std. Beta	t-score	Sig. level
(Constant)	2.38	0.10	---	23.95	0.000
Aid grade	0.01	0.00	0.40	9.32	0.000
Male	-0.18	0.05	-0.15	-3.54	0.000
Unmet need > $10K	-0.29	0.08	-0.15	-3.54	0.000
Minority	-0.28	0.10	-0.12	-2.78	0.006
R-square = 0.252					

Table 5

Multiple regression model of cumulative GPA including TVS status

	Beta	Std. Error	Std. Beta	t-score	Sig. level
(Constant)	2.62	0.22	---	11.85	0.000
Aid grade	0.02	0.00	0.41	5.41	0.000
TVS status	-0.31	0.10	-0.22	-2.99	0.003
Unmet need > 10K	-0.53	0.20	-0.19	-2.69	0.008
Male	-0.17	0.09	-0.14	-2.03	0.044
R-square = 0.381					

Table 6

matched control groups. Results of this analysis showed no significant difference between the two groups on this variable (t=0.88, p=0.38).

Results for At-Risk Students in TVS Group

Based on previous unpublished research at Siena College, we have identified certain clearly defined groups of at-risk students, including Pell grant recipients, under-represented minority students, commuter students, and transfer students. Of the 38 TVS students, 17 fell into one or more of these at-risk groups. All 17 of these students either graduated or persisted to their senior year (i.e. the fall 2014 term), and all 17 maintained a high GPA. In fact, the average final cumulative GPA for these at-risk TVS students was 3.62, compared to 3.60 for the 21 students who did not fall into these at-risk groups.

Discussion

Summary of the Current Study

Four distinct key points emerged from our analyses. First, the TVS group had better outcomes than both the randomly selected comparison group and the matched control group. This was despite the fact that the TVS group had a significantly higher adjusted cohort unmet need compared to the matched controls. Second, the risk analysis demonstrates the importance of unmet financial need as a risk factor for non-retention. Since the TVS program is designed in part to help meet students' unmet need, it is expected that if unmet need is a risk factor for non-retention, the financial support afforded by this program should have a definite effect on retention behavior. Another notable finding of this study is that students with moderately high levels of unmet need ($5-15K) have on average higher cumulative GPAs than predicted. In fact, students in the $5-10K range of unmet need (precisely the gap that the TVS program is most capable of bridging) have a higher average cumulative GPA than students with little or no unmet need. This suggests that overcoming moderately high unmet need can be critical to student performance. Finally, 17 of 38 TVS students had at least one major risk factor (Pell recipient, commuter, transfer, minority), yet all 17 of these students graduated or remain enrolled. The average cumulative GPA of these students was 3.62, suggesting that the TVS program contributed to positive outcomes for at-risk students.

Analysis and Implications

Recalling that the purpose of this study was to determine if participation in the TVS program positively impacted student outcomes, it is clear that both persistence rate and cumulative GPA improvements are observed for the TVS cohort. However, the argument could be made that the randomly selected control group had a lower level of academic preparation or a greater number of risk factors compared to the TVS group, thus confounding the comparison of outcomes. To reduce variation between the control and experimental population, a second analysis was conducted using a carefully matched sample of control subjects. Results indicated that the TVS group had a higher persistence rate compared to the matched controls, but the difference was not statistically significant. The TVS group did have a significantly higher final cumulative GPA compared to the matched controls, but there was no significant difference between the two groups in the change from first term GPA to final cumulative GPA.

Although the matched group analysis provides greater statistical precision in evaluating the results of the present analysis, the comparison with the randomly selected group should not be dismissed. These randomly selected controls were all drawn from basically the same pool of students from which the eventual TVS participants were drawn. Any of the random controls would therefore have been potentially eligible for the TVS grant assuming they earned the appropriate threshold GPA of 3.0 and had some demonstrated financial need, which is the case for most of our students. In fact, as noted in the results section, some of the most striking results of the TVS program were for students in clearly defined at-risk categories, including Pell grant recipients, minority students, commuter students, and transfer students.

Study Limitations and Future Research

Unmet financial need is a strong predictor of non-retention, as demonstrated by the results of this study and previous research (Allard, 2013). However, unmet need is in some sense a moving target, as a student's level of unmet need can easily change, perhaps significantly, from one term to another. The risk analysis in the present study only looked at the level of unmet need at the time of matriculation. Previous research at Siena College suggests that the effect of unmet financial need is attenuated for sophomore students (and by extension, even more so for juniors) (Allard, 2013).

As in any multiple regression analysis, the effect of a single variable is to some extent model-dependent (Norusis, 2011). In other words, a variable which is statistically significant in one of the regression models used in this study might not be statistically significant in a model using a different set of predictor variables (and vice-versa). Therefore results of this study, particularly with reference to the effect of a specific variable (e.g. minority status or Pell grant status), should be interpreted with caution. Although the present study used a range of risk factors, it is certainly possible that there are additional risk factors for adverse academic outcomes that were not identified in this study. Further research will be necessary to identify all relevant risk factors, in order to determine if there are additional confounding variables that may affect the relationship between TVS participation and academic outcomes.

The following are issues that could be investigated for further improving the quality of our results:

- The sample size for the present study was quite small (38 students in the TVS group), thus limiting the statistical power of any comparisons that were made.
- In the second part of the study, the TVS students were carefully matched to control students. However, the matching was imperfect, and it is possible that there are other confounding variables that were not used in the matching procedure, which have not yet been identified.
- Clearly a self-selection bias is at work in the TVS group (Guo & Fraser, 2009), which limits the strength of any conclusions that might be drawn from the results of this study. Students were not randomly assigned to the TVS group; rather, they chose to apply to the program. It is of course possible, and even likely, that students who were not committed to remaining at Siena, or who were not highly motivated to begin with, would not have applied to the TVS program. Therefore, the TVS cohort may have consisted of students who were more motivated to perform well academically, persist in college, and/or remain in a STEM field. Since no data were available on student intent or motivation, we have no way to control for this potential confounding factor.

Conclusions and Recommendations

The preliminary risk analysis indicated a very strong effect for high levels of unmet financial need. Specifically, students with an unmet need of more than $10,000 were much more likely to drop out of Siena College compared to students with lower levels of unmet need; of the 53 students who fell into this high unmet need category, 33 dropped out of Siena. Unmet financial need is in part a proxy for other risk factors; however, since the logistic regression model controls for the effects of other variables in the model, these statistical results suggest that unmet need in itself is a major contributing factor to non-retention. Therefore, any programs that can provide additional funding to students with high levels of unmet need will likely increase retention and graduation rates.

Students with a very high level of unmet need (greater than $15,000) also had a significantly lower final GPA. It is possible that these students are facing multiple stressors, and may need to work longer hours in an attempt to make ends meet. However, what is perhaps most noteworthy in this analysis of unmet need is the fact that students with moderately high levels of unmet need ($5,000 to $15,000) did not show any significant deficits in final GPA compared to students with less than $5,000 in unmet need. In fact, the intermediate group ($5,000 to $10,000) had a higher average cumulative GPA than students in the lowest financial need category. These results indicate that students with moderate levels of unmet need are very

capable of demonstrating a high level of academic success if they remain enrolled. This finding reinforces the importance of providing additional financial support to students with higher levels of unmet need.

The univariate analyses indicated that being a Pell grant recipient was a significant predictor of non-retention and lower cumulative GPA, although Pell grant status dropped out of the multivariate regression models. Pell grant status is typically a proxy for a range of risk factors, often including economic, social, and academic challenges. It is worth noting, however, that there were 10 Pell grant recipients among the eventual TVS participants. All 10 of those Pell grant recipients either graduated from Siena or remain enrolled, with an average final cumulative GPA of 3.49. Thus the TVS program appears to be beneficial to this at-risk group.

Compared to the random control group, the TVS cohort had statistically significant improvements in both persistence and performance. In comparison to the matched control group, both persistence and performance were better for the TVS group, however there was no statistical significance to the improved persistence rate.

We recommend collecting data from NSF S-STEM programs at other institutions and conducting analyses for random control groups and matched-pair control groups based on the methodology presented above. By collecting data with a larger sample size, the statistical significance of the differences in persistence rates may be possible to elucidate. Additionally, the increased sample size can allow for comparison of outcomes at varying institutions and finding both commonalities and discrepancies to the results presented herein. Using the characteristics and profiles of participant schools, a further analysis might illuminate how the experiences students have in varying S-STEM programs compare to this cohort experience. From this analysis, we may gain insight into how cohort and scholarship-based strategies combine to enhance the number and quality of STEM graduates.

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Appendix A. Coding scheme for initial analysis of risk.

The variables used in the risk analysis, along with the coding scheme used in subsequent multivariate analyses.

- Gender: Male students were coded 1; female students were coded 0.

- Ethnicity: Under-represented minority students were coded 1; non-minority and Asian students were coded 0.

- Student type: Students who matriculated as transfers were coded 1; new students were coded 0.

- Residence: Commuter students were coded 1; students living on-campus were coded 0.

- Major: Students with an undeclared science major were coded 1; students with a declared STEM major were coded 0.

- Aid grade: Students with an aid grade of less than 40 were coded 1; other students were coded 0. (Aid grade is a measure of academic preparation, derived primarily from high school GPA and SAT/ACT test scores.)

- Pell status: Pell grant recipients were coded 1; other students were coded 0.

- Unmet need: Students were categorized by the amount of unmet financial need in their matriculation term. For the multivariate

analyses, students with an unmet need of more than $10,000 were coded as 1; other students were coded as 0.

Appendix B. Coding scheme for the logistic regression analysis of graduation and persistence.

The following potential risk factors were included as predictor variables:

- Transfer status: Students who were transfers were coded 1; new students were coded 0.

- Undeclared major: Students with an undeclared science major were coded 1; students with a declared STEM major were coded 0.

- Out-of-state residency: Students with an out-of-state residency status were coded 1; in-state students were coded 0.

- Male: Male students were coded 1; female students were coded 0.

- Minority status: Minority students were coded 1; non-minority students were coded 0.

- Low aid grade: Students with an aid grade of 40 or less were coded 1; other students were coded 0.

- Commuter: Commuter students were coded 1; students living on-campus were coded 0.

- Unmet need: Students with an unmet financial need (for the matriculation term) of more than $15,000 were coded as 1; other students were coded as 0.

- Financial aid status: Students who did not apply for financial aid were coded 1; students who applied for financial aid were coded 0.

- Pell grant recipients: Pell recipients were coded 1; other students were coded 0.

- TVS status: Students who eventually participated in the TVS program were coded 0; non-TVS students were coded 1.

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