2018 ASEE ANNUAL CONFERENCE & EXPOSITION
JUNE 24–27, 2018
SALT PALACE CONVENTION CENTER
SALT LAKE CITY, UT

Paper ID #22320

Correlation Between Academic Credit-use Policies and Student Persistence in Multidisciplinary Vertically Integrated Project (VIP) Courses

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Abstract

In the Vertically Integrated Projects (VIP) Program, undergraduates earn academic credit for their participation in long-term, large-scale, multidisciplinary project teams that are created at the request of faculty to assist them with their research and other innovative activities. The students contribute their disciplinary skills to the project, collaborate with students from other disciplines, and learn and practice many professional skills. A key to launching and maintaining productive VIP teams is having students participate for multiple semesters, sometimes up to six semesters. This allows students to develop deeper expertise and take on increasing levels of responsibility. Academic departments have established a range of credit-use policies for VIP courses, with some departments incentivizing multiple semesters of participation, with different incentives and varying thresholds for each policy. Beyond curricular policies, the number of semesters students participate in VIP may be affected by matches/mismatches between students and their instructors' departments, as well as student academic rank in their first semester of VIP. This study describes policies for the four academic units with highest enrollments in VIP at the Georgia Institute of Technology, and examines the number of semesters students (N = 869) participate in VIP by policy, by academic rank, and by matches-mismatches between student and instructor departments. In a secondary analysis, persistence rates are compared for a degree program before and after an incentivizing credit-use policy was established (N = 45). Results show correlation between higher persistence and two policies: 1) allowing all VIP credits to count as in-major electives after a minimum number are earned; and 2) allowing students to fulfill a design sequence requirement through VIP, with no additional planning/requirements beyond the normal design sequence. The study employed chi-square analysis for all but one analysis, because assumptions for analysis of variance were not met. These findings will be of use to existing and prospective VIP Programs, as well as institutions and departments seeking to increase student persistence in undergraduate research.

Introduction

The Vertically Integrated Projects (VIP) model combines undergraduate education with faculty research. Students earn academic credit for their participation in project teams, and the teams make meaningful contributions to faculty research. The Association of American Colleges & Universities has identified eleven high impact practices correlated with higher graduation rates and greater gains in undergraduate learning [1]–[3]. The Vertically Integrated Projects (VIP) Program combines two of these high impact practices: undergraduate research and collaborative assignments/projects. In some majors, students can fulfill their capstone or culminating design requirements through VIP, thus incorporating another high impact practice (capstone projects).

In a nationwide study of undergraduate research experiences, Russell, Hancock and McCullough found the overall duration of research experiences to be correlated with positive outcomes [4]. The benefit of longer research experiences complements the structure of VIP, as returning students take on increasing levels of responsibility and serve as student leaders. To facilitate longer-term student participation, VIP courses are offered in 1-credit and 2-credit increments, with two semesters of participation equivalent to a single 3 or 4-credit course. Building upon this credit structure, some academic units have established credit-use policies that incentivize multiple semesters of participation in VIP [5]. However, whether curricular incentives yield higher persistence has not been examined.

The VIP model has been adopted by twenty-six colleges and universities, and at the Georgia Institute of Technology (Georgia Tech), additional departments continue to adopt and refine curricular policies regarding the program. This expansion demands reflection on how policies affect student persistence in the VIP program, and how other factors may contribute. We hypothesize that different Georgia Tech credit-use policies affect student persistence in different ways, and seek to identify elements that encourage persistence. Given the multidisciplinary nature of VIP, we consider the match or mismatch between students and their VIP instructors by department. Given the vertical integration of VIP teams (the inclusion of sophomores, juniors and seniors every semester), we also consider the interaction between academic rank and credit policy.

Hypothesis:

- Different curricular polices on how VIP credits can be applied toward degree requirements affect student persistence (number of semesters) in the program in different ways.
- These policies affect students of differing ranks (sophomore, junior, senior) differently.
- Mismatches between student major and instructor field of study do not affect student persistence.

Research Questions:

- What credit-use policies increase student persistence?
- How do credit-use policies affect students who begin VIP at different academic ranks (sophomore, junior, senior)?
- Do matches/mismatches between student fields of study and instructor fields of expertise affect persistence?

The VIP Model

The purpose of the VIP Program is to overcome the fragmentation of higher education by mission, time and discipline by enabling students, faculty and research staff to collaborate in the innovation process. For fragmentation by mission, the modern university is typically partitioned into the three often competing sub-missions of research, education and service. Through VIP, the missions of research, education, and service can often be addressed simultaneously, with student teams embedded in faculty efforts in innovation. For fragmentation by time, campus life is segmented into semesters and academic years, with few learning experiences lasting more than one semester. In VIP, each student can participate for multiple semesters and up to three years, earning academic credit for their contributions toward the research goals of the faculty and graduate students. Projects also last longer than any one students' participation, further overcoming the boundary of time. In the last fragmentation, almost all intellectual activity is classified by discipline, with the budgetary structure of the university reinforcing these disciplinary boundaries. VIP overcomes these boundaries, as the projects are multidisciplinary by nature (Figure 1).

The VIP Program at Georgia Tech began in the School of Electrical and Computer Engineering, but it has expanded significantly. Teams are now led and co-led by faculty and research staff from five of the six colleges on campus, as well as the Georgia Tech Research Institute and other campus units (Figure 2). One third of teams are co-led by instructors from different campus units.

An analysis of university exit surveys showed higher scores and meaningful effect sizes for VIP participants in ability to work in multidisciplinary teams, ability to work with individuals from diverse backgrounds, and understanding of technologies related to student's field [6]. Subsequent social network analysis of student peer evaluations indicated that within VIP teams, students interact more often with classmates from other races/ethnicities than their own, and more often with other majors than their own [7].

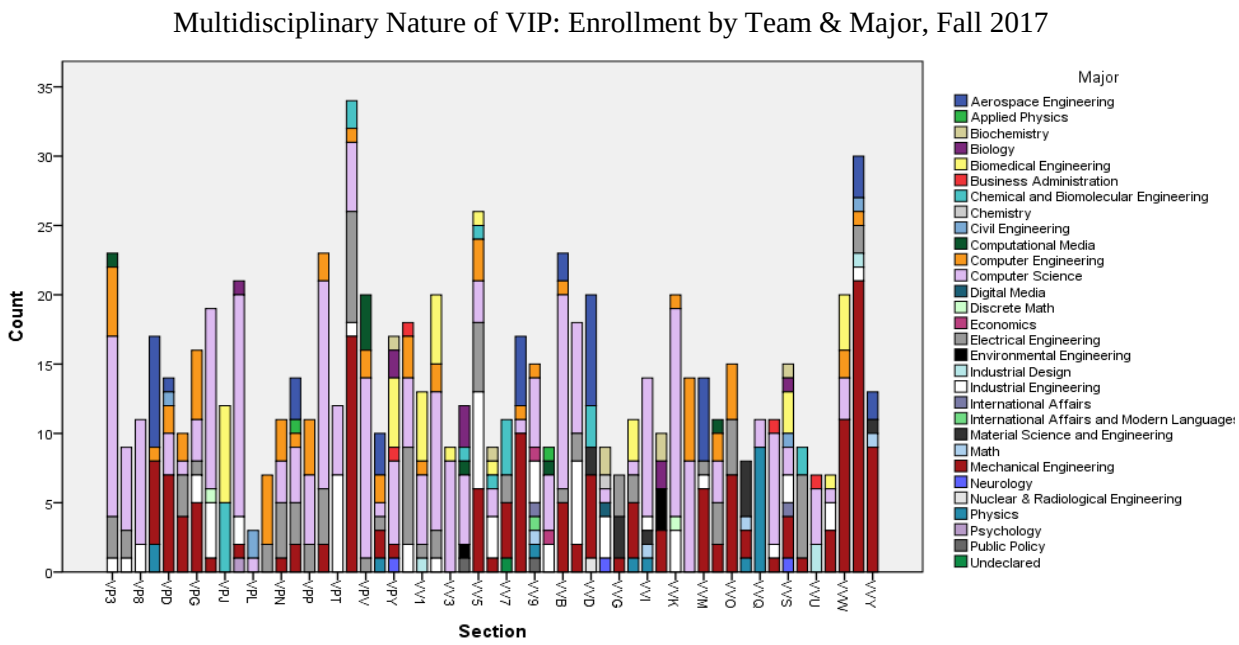

Figure 1. Multidisciplinary Nature of VIP at Georgia Tech

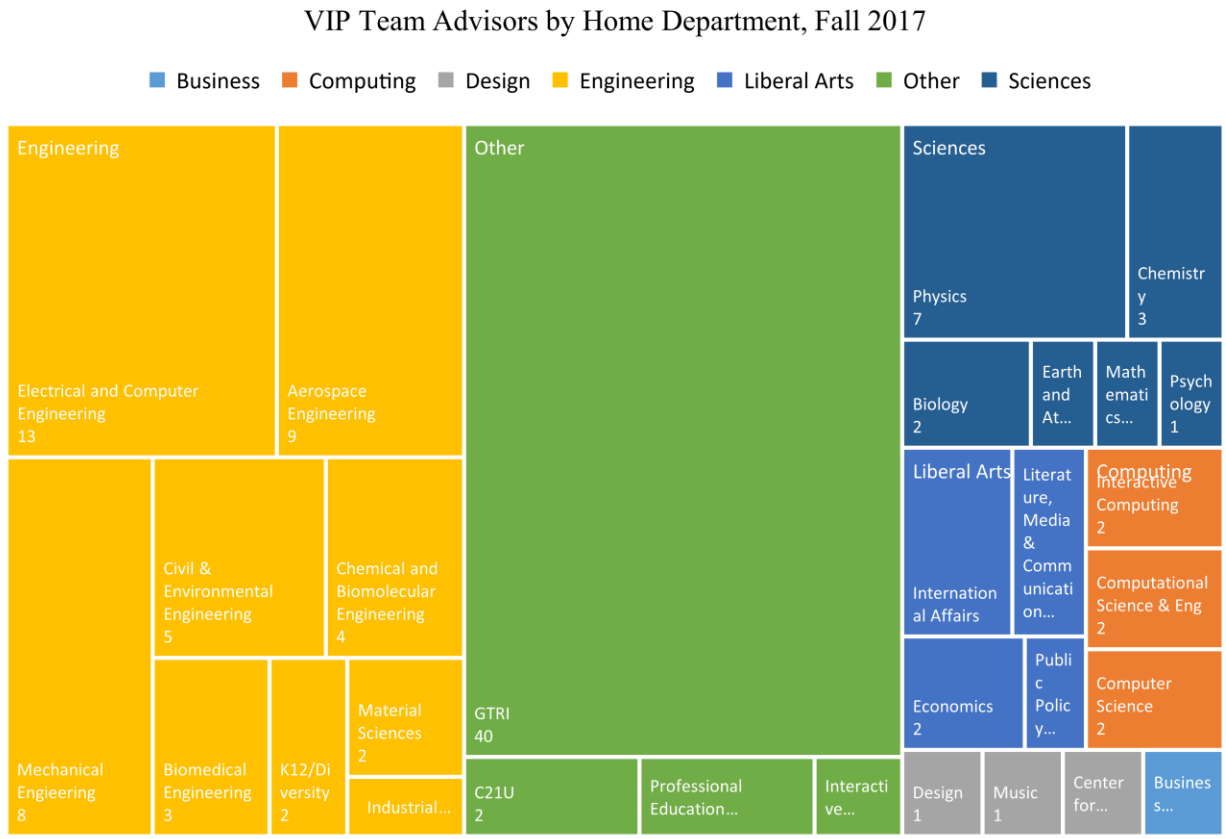

Figure 2. VIP Team Advisors and Co-advisors by Department

Twenty-six institutions of varying sizes and missions have established VIP programs. They include two Historically Black Colleges and Universities; three Hispanic Serving Institutions; AAU, R1, R2, and R3 universities and baccalaureate institutions; public/private and large/small institutions; and, seven institutions outside the US. They are all members of the VIP Consortium, which was formed to facilitate improvement and dissemination of VIP Programs via collaboration amongst VIP sites. To this end, the VIP Consortium identified seven key elements of VIP Programs [8] [9]:

1. *Projects are embedded in faculty mentor's research efforts.*
   VIP teams are started at the request of faculty. Under their mentoring, the teams learn about and contribute to the research effort. This long-term, mutually beneficial engagement between faculty and students is the foundation of the success of the VIP Program.

2. *Projects are long-term and large-scale, continuing for many years, even decades.*
   The VIP team model allows for larger-scale and longer-term projects than a single semester or year would permit. This allows faculty to take on more ambitious projects; it gives new students experience in coming up to speed on an existing project - as they'll inevitably need to do in a future workplace; and, it gives returning students leadership experience, as they help on-board and organize the activities of new members.

3. *The program is curricular and all participating students are graded (A-F; not P/F or S/U).*
   VIP is not an extra- or co-curricular activity. It is a sequence of courses whose credits count towards students' degree requirements. Letter grading holds students accountable for their work. In many ways, feedback and grading in VIP is like an evaluation in the workplace. Work is evaluated, guidance is given, and students have the opportunity to improve.

4. *Students can participate and earn credits toward their degrees for at least two years.*
   Long-term student participation is the key to team success. When new students join a team, which occurs every semester, they spend much of their first semester coming up to speed on the project. They then make significant disciplinary, teamwork, and leadership contributions in subsequent semesters.

5. *Learning outcomes focus on the development of both disciplinary and professional skills.*
   VIP teams function much like small start-up companies. While students develop and apply skills from their disciplines, they also develop and apply professional skills that are important to team functioning and will be of great value to them in their future careers.

6. *Multi-disciplinary teams are encouraged but not required.*
   Multi-disciplinary teams are a hallmark of VIP programs, giving faculty access to the variety of disciplines and skill sets needed for projects to succeed. A new VIP site may initially be limited in disciplinary scope by departmental or curricular rules, but examples of successful multidisciplinary projects elsewhere in the Consortium can help overcome these barriers.

7. *Dedicated classroom and meeting spaces.*
   VIP teams do not function like traditional classes, so it is important to provide spaces in which the teams can meet and collaborate. Teams typically meet at the same time and day each week, ensuring that team meetings work well with instructors' schedules. Student access to the space outside of scheduled class times allows for sub-team meetings. Rooms are typically set up in conference style to facilitate collaboration. [9]

Because Consortium institutions vary in many characteristics (size, student preparation, public/private, etc.), they have implemented their VIP programs in varying ways. More about the implementations can be read in a collaborative paper by authors from sixteen consortium institutions [8].

Curricular Incentives

Curricular policies are set by academic departments and vary. Seventeen degree programs at Georgia Tech have policies regarding VIP credit use toward degree requirements, with each incorporating one or more incentive levels. At the lowest incentive level, VIP credits can count as free electives. At the intermediate incentive level, VIP credits can count as in-major or technical electives, which is generally more desirable. At the highest incentive level, VIP can be used to fulfill design sequences for junior or senior capstone requirements.

In addition to varying incentive levels, policies also differ in their use of thresholds or minimum requirements needed to qualify for the incentive. For example, one department allows students to use VIP credits as in-major electives, regardless of the number of VIP credits earned. This may serve as an incentive for initial enrollment, allowing students to earn the number of credits they need, but it does not encourage long term involvement. Another program allows students to use VIP as in-major electives, but only after six VIP credit hours are earned. With VIP offered in 1 and 2-credit hour increments, this would require at least three semesters of participation. The in-major electives may encourage students to participate for multiple semesters, but students who do not need the full six credits of in-major electives may be less inclined to participate.

As the incentive levels increase, the complexity of threshold options also increases. In two policies in engineering disciplines, VIP can be used to fulfill Senior Design requirements. In both, students must participate in VIP for two semesters *prior to* Senior Design. With two-semester Senior Design sequences in both departments, students on this track would need to begin VIP at the start of their junior years in order to take advantage of the option. This means they would need to apply to and register for VIP at the end of their sophomore year, which requires substantial advance planning.

To compound the question of how policies impact student persistence in the program, policies may have differing effects on students of different academic ranks. As an example, consider a sophomore and a senior who are interested in VIP, who have not yet participated in the program. If a policy requires students to participate for three semesters in order to earn an incentive, the sophomore may view the policy favorably, because he/she needs the incentive being offered and has three semesters available in his/her timeline to graduation. The senior may view the policy less favorably, as he/she may not need the incentive so late in his/her academic career, and he/she may not have enough semesters remaining in his/her timeline to graduation.

Another factor that may shape student persistence is the match or mismatch between a student's major and the instructor's academic department. VIP teams are multidisciplinary. Instructors come from many departments, and the program attracts students from 20+ fields of study. While the concept of multidisciplinary experiences is desirable – and we have seen statistically significant gains in VIP students' graduation exit surveys on multiple factors [6], [7] – whether students persist in the program when instructors are from other departments is an important question. If students are less likely to persist in these mismatch cases, should they be advised accordingly? Or are collaborations or co-advising with instructors from home-departments necessary to effectively serve students from multiple majors?

Methods

Cohorts

The primary analysis focused on students in four cohorts. The earliest cohort consisted of students who first enrolled in VIP in Spring 2014. While the program has been offered since Spring 2009, a new website and new recruiting methods were implemented in Fall 2014, which may have changed student understanding of credit-use policies from Fall 2014 forward. The most recent cohort consisted of students who first enrolled in VIP in Fall 2016, allowing students one more semester (Spring 2017) to participate in VIP again before the analysis. We initially planned to include fewer cohorts, to focus on differences by number of semesters of participation (one to six). However, statistical tests limited the analysis to two groupings of one semester and of two or more semesters. While not ideal, this allowed the inclusion of more recent cohorts, as students planning to complete four semesters would still be grouped with the "two or more" group immediately after their second semester.

The secondary analysis considered persistence prior to and after the adoption of a curricular incentive. Initial examination indicated that students could be grouped by one, two, and three or more semesters. To this end, fewer cohorts were used (Spring 2014 through Spring 2016), to allow the most recent cohort enough time to participate for a third semester.

Policy Selection for Study

Criteria used to select majors for inclusion in the primary analysis were:

1) That there was a credit-use policy in place during all semesters included in the study;
2) That there were no significant changes to the credit-use policy between Fall 2014 and Spring 2017;
3) That the cohorts include at least 100 students from the degree program.

Five majors in four departments met the criteria above, with one in the College of Computing and four in the College of Engineering. Two majors are administered by the same department and have the same credit-use policies, and were categorized under one policy. This yielded four policy groups. Because the focus of the study is on credit-use policies and not on the programs of study, analysis and results are reported with respect to the policies and not the majors.

In the review of credit-use policies, we found one major adopted a credit-use policy in Fall 2015, with no prior policy in place. Fifty-eight students from the major were in the cohorts studied, which was below the 100-student threshold. However, the adoption of a new policy allowed for a pre-post comparison, so a secondary analysis was conducted for this major. As described above and later, fewer cohorts were used in this analysis, reducing the number of students to 45.

The four policies chosen for the primary analysis and the fifth for the secondary analysis are profiled in Table 1. The policies in the primary analysis are ordered by perceived level of incentive. The lowest incentive level (Policy 1) allows VIP credits to count as free electives. The next level of incentive allows VIP credits to count as in-major or technical electives. Two of the policies require a minimum number of VIP credit hours in order for credits to be used in this way (Policies 3 and 5), while another does not (Policy 2). The highest perceived level of incentive allows students to use their VIP experiences to fulfill

Table 1. Policies and Prerequisits/Thresholds for Incentives

	Policy	Incentives & Maximum Credits	Prequisites/Thresholds for Incentives In Semesters		In Credits
Primary Analysis	Policy 1	Free elective: up to 6 credits			
	Policy 2	In-major electives: up to 3 credits			
		Senior Design	2 semesters of VIP prior to Senior Design	=	3 credits of VIP prior to Senior Design
	Policy 3	Partial in-major electives: 3 free, 3 in-major	3-4 semesters of VIP	=	6 credits of VIP
		Senior Design	3 semesters of VIP prior to Senior Design II	=	5 credits of VIP prior to Senior Design II
	Policy 4	Junior Design	*		-1 credit*
Secondary Analysis	Policy 5	In-major elective: 6 credits	3-4 semesters of VIP	=	6 credits of VIP

* VIP is one of two options for Junior Design, both with the same number of semesters, but the VIP option is one credit less.

a multiple semester design sequence. Two policies require additional semesters of VIP prior to the typical Senior Design semesters (Policy 2 and 3), while another for Junior Design does not (Policy 4).

Data

Enrollment records were obtained for the full history of the VIP program through Spring 2017, to identify students who first enrolled during the six-semester cohort window for the primary analysis, and five cohorts for the secondary analysis. Students who changed majors between their semesters of VIP participation were treated as having the second major, because it was under the second major (and second policy) that they returned to the program. Freshman were removed from the data set, because they are not typically allowed to participate, and the small number in the cohorts was too small for effective analysis (*N*=12). The final data set consisted of 869 students for the primary analysis, and 45 for the secondary analysis (Table 2).

Table 2. Policy Summaries and Groupings

	Policy Group	Policy		N
Primary Analysis	1	Free elective		210
	2	In-major elective no minimum Sr. Design with prerequisites		117
	3	Partial in-major elective with minimum Sr. Design with prerequisites		286
	4	Jr. Design no prereq., no prerequisite		256
			Total	869
Secondary Analysis	5	In-major elective with minimum		45

Statistical Tests

Primary Analysis, Four Policies

We planned to conduct an analysis of variance, with student participation ranging from one to six semesters. However, Levene's test of homogeneity was significant for all but one analysis, indicating that an analysis of variance would not be appropriate in those instances. Chi-square analysis was used in those instances instead. In a chi-square analysis, categories are tabled against each other, with one set of

categories defining rows (policies), and the other set of categories defining columns (number of semesters of participation), with the frequencies used in the grid (Table 3) used to compute a chi-square test for differences. For an effective chi-square analysis, the number of cases in each cell should not be less than five.

Table 3. Cross tabulation example

Cross tabulation Example

		Number of Semesters in VIP			
		1 Semester	2 Semesters	3 Semesters	4 Semesters
Majors	Major 1	#	#	#	#
	Major 2	#	#	#	#
	Major 3	#	#	#	#

While multiple semesters of participation are encouraged, they are not required. Approximately half of VIP students participate for one semester, a quarter participate for two semesters, and a quarter participate for three or more semesters. To avoid creating cross-tabulation cells with fewer than five students, and to simplify the additional analysis of student rank and professor-student match-mismatch by department, participation was divided into two levels: one semester and two or more semesters. Chi-square analysis was used to examine student persistence by 1) policy and by 2) the interaction between policies and student academic rank upon first enrollment in VIP. A separate analysis was done for each.

Levene's test of homogeneity was not significant for persistence by match/mismatch between student and instructor departments, so an analysis of variance was used. Instructors from non-academic units such as the Georgia Tech Research Institute were coded as belonging to the department with which they were affiliated as instructors, or if alumni, the department from which they graduated. Instructors from other campus units without clear affiliations with a degree-granting department were coded as "other," yielding no matches with students by major. One third of VIP teams are led by instructors from two different campus units. If a student major matched the department of any of his/her instructors, the student was coded as matching the instructor department.

Secondary Analysis, Pre-Post

In a secondary analysis, persistence rates for a single degree program were compared for semesters prior to and after the establishment of a credit-use policy. Levene's test of homogeneity was significant, again indicating that an analysis of variance would not be appropriate, so a chi-square test was again used. Because both groups included students who participated for one, two and three semesters, the levels for the persistence category were one, two, and three or more semesters. To maintain consistency for this grouping, fewer cohorts were included, to allow the most recent included cohort enough time to complete a third semester.

Results

Persistence by Policy

In the first analysis, we examined student persistence with respect to credit-use policy. When considered as percentages, students returned at a rate of 48% under the free elective policy; 36% under the policy with in-major electives with no minimum and Senior Design with prerequisites; 52% under the partial in-major elective and Senior Design with prerequisites policy; and 68% under the policy for Junior Design with no prerequisites (Table 4, Figure 3). The chi-square test indicated the relationship between credit use policy and student persistence was significant, with $\chi^2(3, N = 869) = 45.891$, $p < .001$ (Table 5).

Table 4. Cross Tabulation of Student Persistence in VIP with Respect to Credit-use Policy

Policy Group	N		1 Semester Count	1 Semester Standardized Residual	2 or + Semesters Count	2 or + Semesters Standardized Residual	Return Rate
1 Free elective	210	Actual	119	1.9	91	-1.8	43%
		Expected	99.8		110.2		
2 In-major elective no min. Sr. Design w/ prerequisite	117	Actual	75	2.6	42	-2.5	36%
		Expected	55.6		61.4		
3 Partial in-major elective w/ min. Sr. Design w/ prerequisite	286	Actual	138	.2	148	-.2	52%
		Expected	135.9		150.1		
4 Jr. Design no prerequisite	256	Actual	81	-3.7	175	3.5	68%
		Expected	121.7		134.3		

Table 5. Chi-square Results for Student Persistence by Credit Use Policy

Grouping	N	df	Pearson Chi-square	p
Policies	869	3	45.891	***

*** $p < .001$

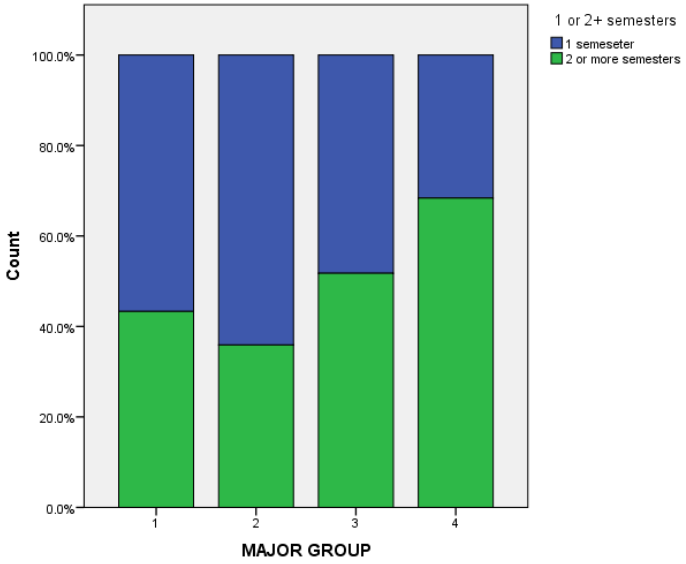

Figure 3. Student Persistence in VIP by Credit Use Policy

Persistence by Policy and Academic Rank

The second analysis examined the interaction between policies and student academic rank upon first enrollment in VIP. A chi-square test indicated significance for policy group 4, with $\chi^2(2, N = 256) = 6.385$, $p < .05$ (Table 7). Under this policy, students returned at a rate of 59% for those who first enrolled as sophomores, 75% for those who started as juniors, and 72% for those who started as seniors (Table 6, Figure 4). For other policies, the differences were not statistically significant.

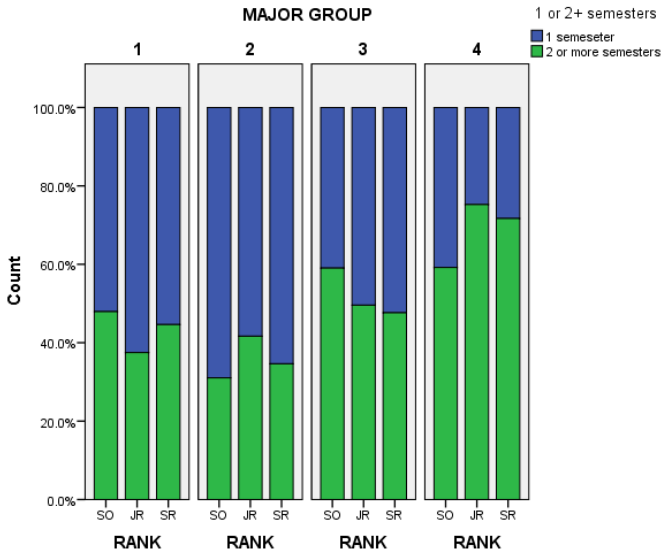

Figure 4. Student Persistence by Policy and Academic Rank upon First Enrollment in VIP

Table 6. Cross Tabulation of Student Persistence in VIP by Credit-use Policy and Academic Rank upon First Enrollment in VIP

				1 Semester		2 or more semesters		
Policy Group	Rank	N		Count	Standardized Residual	Count	Standardized Residual	Return Rate
1 Free elective	SO	73	Actual	38	-.5	35	.6	48%
			Expected	41.4		31.6		
	JR	72	Actual	45	.7	27	-.8	38%
			Expected	40.8		31.2		
	SR	65	Actual	36	-.1	29	.2	45%
			Expected	36.8		28.2		
2 In-major elective no min. Sr. Design w/ prerequisite	SO	29	Actual	20	.3	9	-.4	31%
			Expected	18.6		10.4		
	JR	36	Actual	21	-.4	15	.6	42%
			Expected	23.1		12.9		
	SR	52	Actual	34	.1	18	-.2	35%
			Expected	33.3		18.7		
3 Partial in-major elective w/ min. Sr. Design w/ prerequisite	SO	83	Actual	34	-1.0	49	.9	59%
			Expected	40.0		43.0		
	JR	119	Actual	60	.3	59	-.3	50%
			Expected	57.4		61.6		
	SR	84	Actual	44	.5	40	-.5	48%
			Expected	40.5		43.5		
4 Jr. Design no prerequisite	SO	98	Actual	40	1.6	58	-1.1	59%
			Expected	31.0		67.0		
	JR	105	Actual	26	-1.3	79	.9	75%
			Expected	33.2		71.8		
	SR	53	Actual	15	-.4	38	.3	72%
			Expected	16.8		36.2		

Table 7. Chi-square Results for Student Persistence by Credit Use Policy and Academic Rank Upon First Enrollment

Policy Group	N	df	Pearson Chi-square	p
1 Free elective	210	2	1.674	.433
2 In-major elective no min. Sr. Design w/ prerequisite	117	2	.856	.652
3 Partial in-major elective w/ min. Sr. Design w/ prerequisite	286	2	2.563	.278
4 Jr. Design no prerequisite	256	2	6.385	*

* $p < .05$

Persistence by Match/Mismatch between Student and Instructor Department

The third analysis considered student persistence by match/mismatch between student majors and instructor departments. With match-mismatch as the independent variable and number of semesters as the dependent variable, Levene's test of homogeneity was not significant, indicating an analysis of variance would be appropriate. Analysis of variance showed no significance at the .05 level, as shown in Table 8 and illustrated in Figure 5.

Table 8. Analysis of Variance of Number of Semesters in VIP by Match/Mismatch between Student and Instructor Departments

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.548	1	1.548	1.986	.159
Within Groups	675.619	867	.779		
Total	677.167	868			

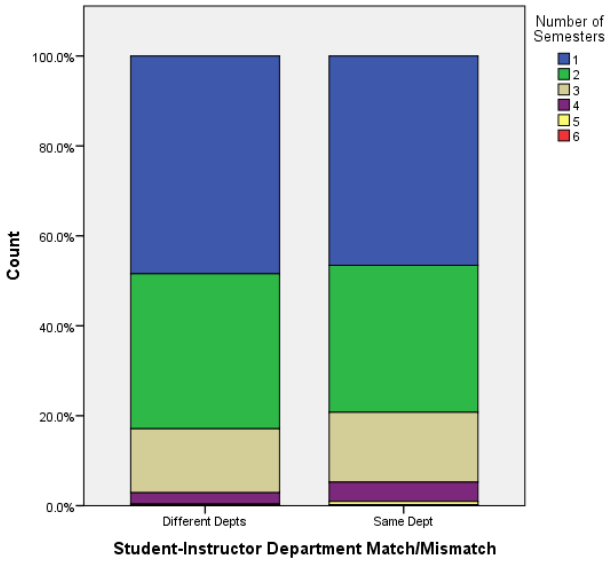

Figure 5. Student Persistence by Match/Mismatch between Student and Instructor Department

Persistence prior to and after Curricular Incentive Adoption

In a secondary analysis, persistence rates for a single degree program were compared for semesters prior to and after the establishment of a credit-use policy. Levene's test of homogeneity was significant, indicating that an analysis of variance would not be appropriate, so a chi-square test was again used. Because both groups included students who participated for one, two, and three or more semesters, the levels for the persistence category were one, two, and three or more semesters. One of the six cells in the cross-tabulation had a value less than 5. The results showed statistical significance, with $\chi^2(2, N = 45) =$

6.30 , $p < .05$ (Table 10). The percentage of students participating for three or more semesters was 7% before the incentive and 43% after (Figure 6, Table 9).

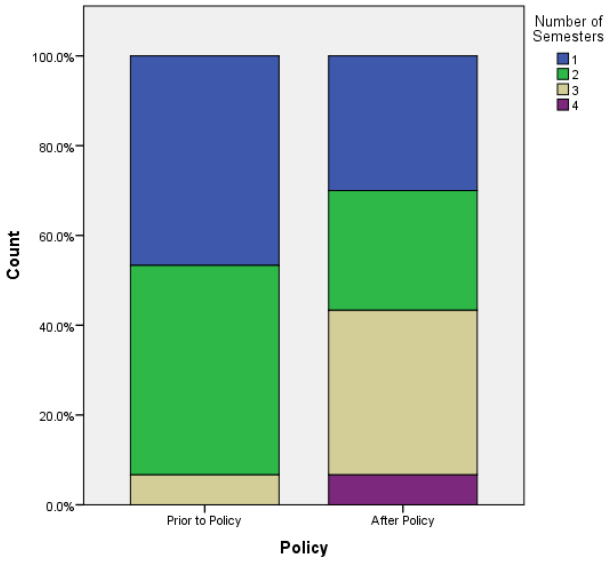

Figure 6. Student Persistence in VIP Prior to and after Adoption of a Curricular Incentive

Table 9. Cross Tabulation of Student Persistence in VIP prior to and after Adoption of a Curricular Incentive

				1 Semester		2 semesters		3 or + semesters			
Policy	Time	N		Count	Stand. Residual	Count	Stand. Residual	Count	Stand. Residual	% 2 or + Semesters	% 3 or + Semesters
5 In-major elective w/ minimum	Prior to Policy	15	Actual	7	.7	7	.9	1^	-1.7	53%	7%
			Expected	5.3		5.0		4.7			
	With Policy	30	Actual	9	-.5	8	-.6	13	1.2	70%	43%
			Expected	10.7		10.0		9.3			

^ Cell contained less than 5 cases.

Table 10. Chi-square Results for Student Persistence prior to and after Curricular Incentive Policy Adopted

Policy Group	N	df	Pearson Chi-square	*p*
5	45	2	6.303^	*

$p < .05$

^ 1 cell had an expected count less than 5.

Discussion

Persistency by Policy

We hypothesized that different policies yield differing levels of student persistence, which the analysis supports. Persistence with respect to policy was statistically significant. Upon inspection of the data, there is a clear difference between Policy 4 and the others, with 68% of students returning for a second semester. This policy allows students to fulfill their Junior Design requirement with participation in VIP, with no additional semesters required prior to starting the Junior Design sequence through VIP. In contrast, the two policies involving Senior Design require students to complete two semesters of VIP prior to the Senior Design sequence. This requires students to begin VIP at the beginning of their junior year, for which they would register during the second semester of their sophomore year. This degree of

planning may limit the number of students who make use of this incentive, leaving the lower-level incentives from the respective policies (Policy 2 and 3) for students who do not plan that far ahead.

Policy 1, which offers free electives, was presumed to be the least incentivizing, but with 43% of students returning for a second semester, it did not have the lowest return rate. Few students need free electives, so it can be assumed that students under this policy persisted because of their interest in and connections with their teams.

Policy 2 showed the lowest persistence of the policies studied, with a 36% return rate. In addition to the Senior Design option with prerequisites (which requires advance planning and may limit student participation), the policy allows students to use VIP credits as technical electives, with no minimum required. From experience, we know that some students from the degree program need one or two more technical elective credits to graduate (as students mention it in applications and email inquiries). Few 1 or 2-credit engineering courses are offered, and the VIP structure allows students to earn the needed number of credits without having to pay for or expend effort on additional credit hours. As a result, for this particular major, VIP may attract students who are more interested in the flexible-credit option than in the projects, yielding lower persistence than the free-elective model under Policy 1.

Finally, in addition to having a Senior Design option with a prerequisite (again, which requires advance planning and may limit student participation), Policy 3 also offers partial in-major credit with a minimum requirement. If students earn five credit hours, all five count as free electives. If students earn a sixth credit hour, three count as in-major electives, and three count as free electives. This requires students to participate for three to four semesters in order to earn three in-major electives. The policy yields a return rate of 52%, compared to 43% for the free-elective policy and 70% for the all in-major elective policy considered in the secondary analysis. This implies that splitting credits between in-major and free electives is more effective than free electives alone, but less effective than allowing all six to count as in-major electives.

Persistence by Policy and Academic Rank

We hypothesized that different credit-use policies affect sophomores, juniors and seniors differently. Again, we found statistical significance. We anticipated that some incentives were less appealing than others, based upon student rank upon first enrollment in VIP. Upon visual and numeric inspection of the data, the differences between sophomores, juniors and seniors are not stark for any of the four groups. Closer inspection shows the biggest difference occurs under Policy 4 (associated with the highest persistence), with a 16% difference in the return rate between sophomores (59%) and juniors (75%). The policy allows students to use VIP to fulfill their Junior Design requirement, which may retain sophomores at a lower rate. However, the return rate for sophomores in the group is still higher than for any academic rank in any other major in the primary analysis, indicating that the policy isn't necessarily a disincentive.

Persistence by Match-Mismatch between Student and Instructor Department

In our third analysis, we considered the effect of matches and mismatches between student major and instructor department. We hypothesized that instructor-student matches or mismatches by discipline do not affect student persistence, which was supported by the analysis. This implies that VIP teams effectively engage students from a variety of majors, regardless of whether students are from the same department as their instructors.

Persistence prior to and after Curricular Incentive Adoption

As a secondary analysis, we considered pre- and post-policy adoption enrollments. Under Policy 5, VIP credits can be used as in-major electives, but only if students earn a minimum of six credits. Analysis showed a statistically significant difference. Before the policy was adopted, 53% of students participated for two or more semesters, with 7% participating for three. After the policy was implemented, 70% of students participated for two or more semesters, with 43% participating for three. While policy structures were the focus of this study, traits specific to this department underlie the baseline persistence. *Before* the policy was adopted, when compared to the persistence rates from the initial analysis, this major was tied with the second highest rate. We speculate this relates to the instructional approach of the department. The program includes scaffolded project-based learning, with development based in cognitive and learning science research [10]. Students from this major who enroll in VIP are have sought out additional project-based learning experiences, may have more realistic expectations for the experience, and likely begin with stronger skillsets than students from other degree programs. After the policy was adopted, the return rate *exceeded* the highest rate from the initial analysis. Beyond the scope of this study, these results imply other departments could learn from the educational innovations employed in this major.

Limitations

This study examined student semesters of participation in the VIP Program with respect to credit use policies, academic rank, and match/mismatch between student and instructor departments. A limitation of the study is that it only examined six majors, while the program enrolls students from over twenty degree programs. Another limitation is that it did not consider other differences between departments and degree program requirements, such as available electives, advising practices, etc. These factors are beyond the scope of this study, but are important to recognize in program development and management.

In the analysis of pre-post persistence for Policy 5, one cell in the Chi-square analysis was less than five. This weakens the validity of the test, but we felt the difference between the two groups for the third category was justified.

Also important to consider are the goals underlying differing policies. Lower persistence does not equate to an ineffective policy if the policy was not intended to encourage multiple semesters of participation. Of the five policies studied, three involve incentives for multiple semesters of participation. Whether a policy supports higher persistence and whether a department chooses to incentivize it are two different questions.

Conclusion

The VIP Program provides undergraduate research experiences through faculty-led projects that support their research endeavors. VIP teams are multidisciplinary and enroll sophomores, juniors and seniors (as well as graduate students). Students earn academic credit, and teams contribute to faculty research. Russell, Hancock and McCullough found the overall duration of research experiences to be correlated with positive outcomes [4], and some departments at Georgia Tech incentivize multiple semesters of participation in VIP. This study considered the number of semesters students participated in VIP for five majors with the highest enrollment in the program, grouped into four curricular policies. The study also considered persistence for a sixth major prior to and after adoption of a credit-use policy. The lowest persistence in the program occurred under a policy that allows VIP to count as in-major or technical electives, with no minimum number of credits required. The highest persistence occurred under 1) a policy that allows VIP to fulfill a multi-semester design sequence, with no pre-requisites or additional semesters required, and 2) a policy allowing six VIP credits to count as in-major electives once six credits are earned (involving three to four semesters). The policy built around a Junior Design sequence has

lower sophomore persistence compared to juniors and seniors in the major, yet the sophomores still have higher persistence than other majors in the initial analysis. Results showed higher persistence for a major that employs scaffolded project-based learning. These findings will be of use to existing and prospective VIP Programs, as well as institutions and departments seeking to increase student persistence in undergraduate research.

With regard to the VIP model, there was no correlation between student persistence and the match or mismatch between their majors and their instructors' home departments. This implies VIP teams effectively engage students from a variety of majors, regardless of instructor home department. This is an important factor for institutions considering establishing VIP Programs, and to existing programs seeking to expand VIP to other departments.

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