

2018 CoNECD - The Collaborative Network for Engineering and Computing

Diversity Conference: Crystal City, Virginia Apr 29

## **Diversity and Student Persistence in the Vertically Integrated Project (VIP) Course Sequence**

### **J. Sonnenberg-Klein, Georgia Institute of Technology**

Assistant Director, Vertically Integrated Projects (VIP) Program, Georgia Institute of Technology; Doctoral student in Education at Georgia State University, with a concentration in Research, Measurement and Statistics; Master of Education in Education Organization and Leadership, University of Illinois at Urbana-Champaign; Bachelor of Science in Engineering Physics, University of Illinois at Urbana-Champaign.

### **Prof. Edward J. Coyle, Georgia Institute of Technology**

Edward J. Coyle is the John B. Peatman Distinguished Professor of Electrical and Computer Engineering, directs the Arbutus Center for the Integration of Research and Education, and is the founder of the Vertically-Integrated Projects (VIP) Program. He is also Georgia Research Alliance Eminent Scholar and was a co-recipient of both the National Academy of Engineering's 2005 Bernard M. Gordon Award for Innovation in Engineering and Technology Education and the ASEE's Chester F. Carlson Award. Dr. Coyle is a Fellow of the IEEE and his research interests include systemic reform of higher education education, wireless and sensor networks, and signal and information processing.

### **Dr. Randal T Abler, Georgia Institute of Technology**

# **Diversity and Student Persistence in the Vertically Integrated Project (VIP) Course Sequence**

## **Abstract**

While historically underserved students derive differentially greater benefits from participation in research with faculty, they engage in the activity at lower rates than their peers. In contrast to the national trend, the Vertically Integrated Projects (VIP) Program at the Georgia Institute of Technology enrolls representative proportions of Black/African American students and Hispanic/Latino students with respect to the campus population. This study examines student persistence in the VIP course sequence with respect to race and ethnicity. The VIP model is unique, in that it fully engages faculty; is cost effective, building on existing faculty research interests and efforts; and is fully scalable, with the potential to serve every student at a given institution. The model has been adopted by 24 institutions of varying sizes and varying levels of research activity, including large research institutions, Historically Black Colleges and Universities, and Hispanic Serving Institutions. The VIP implementation at Georgia Tech is not tailored to serve specific subgroups, but aims to serve all students. With current enrollments of 900 students each semester and continued growth, serving every student is a realistic possibility. This paper examines student persistence in the VIP course sequence, and provides an overview of the VIP Program, including common elements across VIP sites, prior research on student interactions within teams by race/ethnicity, and aspects of the Georgia Tech implementation of VIP which may contribute to student diversity within the program. Findings indicate that students of different races and ethnicities persist in the VIP course sequence at equal rates.

## **Introduction**

Undergraduate research is recognized as a high impact experience, which means it is correlated with higher graduation rates and greater gains in undergraduate learning [1]–[3]. While high impact experiences benefit all students, they are correlated with greater gains for historically underserved students [2]. For example, Hispanic students who participate in high impact experiences see greater gains in GPA, with increasing numbers of experiences increasing their GPAs above those of white students who participate in the same number of experiences. Similarly, African American student persistence increases with the number of high impact experiences, exceeding the persistence of white students who participate in the same number of high impact experiences [2]. However, historically underserved students and transfer students participate in research with faculty at lower rates than their peers. Where white and Asian students participate at rates of 23% and 25%, black and Hispanic/Latino students have participation rates of 18% and 19% respectively, as shown in Table 1 [4]. The difference is more pronounced for transfer students and first-generation students, with 15% for transfer vs. 30% for students who started as freshmen, and 18% for first generation vs. 28% for non-first generation [4].

In contrast to these national trends, the Vertically Integrated Projects (VIP) Program at the Georgia Institute of Technology shows consistent representative enrollment for black and Hispanic/Latino students when compared with the campus population. We posit that these

enrollment patterns are not the product of targeted recruiting or a specially tailored program, but reflect student response to a program designed to serve all students.

The National Academies and the Association of American Colleges and Universities have called on institutions to examine participation rates in high impact practices, to determine if students are participating equitably [1], [5]. This paper represents a program-level answer to this call, with an examination of student participation and persistence in the VIP course sequence by race/ethnicity. This paper also provides background on VIP, profiling the model that is now in place at 24 institutions; highlighting prior research on student interaction within Georgia Tech VIP teams by race/ethnicity; and presenting aspects of the Georgia Tech VIP Program which may contribute to student diversity.

*Table 1. Participation in Research with Faculty*

Category	Subgroup	Research with Faculty (%)
Race/Ethnicity	Black or African American	18
	Hispanic or Latino	19
	Asian	23
	White	25
Transfer status	Started at institution	30
	Transfer student	15
First-generation status	Not first-generation	28
	First-generation	18

Table based on summary report from the National Survey of Student Engagement, “NSSE 2017 High-Impact Practices: U.S. Summary Percentages by Student Characteristics,” Indiana State University, 2017 [4].

## Background

### *The VIP Model*

The VIP model was developed in 2001 at Purdue University, and it unites faculty research and undergraduate education in a team-based context. The model is named for the vertical integration of sophomores, juniors, seniors, graduate students and faculty within VIP teams. In VIP, faculty lead student teams on projects that contribute to their research, and teams last for many years, if not indefinitely. Students earn academic credit and can participate for multiple quarters/semesters and years. Projects last longer than any individual student, so teams maintain detailed documentation, returning students onboard new students, and lower level students replace upper level students as they graduate. In 2014, through a grant from the Helmsley Charitable Trust, 14 colleges and universities formed the VIP Consortium. The consortium defined key elements of the VIP model (identified in bold below), based largely on lessons learned at the longer-running program sites. This section draws on the key elements identified by the consortium [6], as well as a collaborative paper written by consortium members [7].

In VIP programs across the consortium, **learning outcomes focus on the development of both disciplinary and professional skills**. VIP students apply skills from their respective disciplines to advance their projects. At the same time, they learn and apply professional skills in planning, teamwork, communication, and conflict resolution. The large-scale, long-term projects mirror situations students will encounter in the workforce. As they join large ongoing projects, they are onboarded by peers, while also taking responsibility for their own learning as they get up to speed. They deal with decisions made in previous years and with documentation developed by

others; conversely, their own documentation will become a reference for the team in the future. Students also learn and apply professional communication skills, communicating problems to appropriate teammates and navigating conflict. These skills are addressed in peer evaluations, with instructors providing feedback at midterms and at the end of the semester. This feedback loop allows students to address areas in need of improvement prior to the end of the semester, and then again before their next semester with the team.

VIP teams include a mix of **lower and upper level students**, even in a team's first semester. Students can participate for at least two years, with credit-use options described below. With this model for team composition, experienced students help onboard new students through student-developed tutorials, modules, and peer mentoring. This lessens the burden on faculty in getting new students up to speed, creates rich experiences for both new and experienced students, and parallels the work students will do in the workplace as they join existing projects and onboard new colleagues. Maintaining a mix of sophomores, juniors and seniors is important in this cycle, so lower level students can take the place of upper level students as they graduate. To support transitions between semesters, students maintain rigorous documentation of their efforts, typically in the form of VIP notebooks, team wikis, and institution-approved electronic portfolios.

As mentioned above, **students can participate in VIP for at least two years**. Two factors make this possible. First, students earn one to two credit hours each semester, a lower number than for a typical course. If VIP were offered for three credit hours each semester, students would accumulate more credits over multiple semesters than their degree programs could accept. Second, credit-use policies for degree programs allow VIP credits to count toward students' degree requirements in meaningful ways. These policies include free electives, in-major electives, and options for using VIP to fulfill culminating design projects [8]. A recent study showed two policies yielded higher persistence in the VIP course sequence at Georgia Tech [9]. One allows students to use VIP to fulfill a multi-semester junior design requirement without prior VIP participation, with 74% of juniors and seniors participating for two or more semesters. (The sophomore participation rate is lower in this major, because the policy is aimed at sophomores and juniors.) The other policy allows all VIP credits to count as in-major electives once a 6-credit (3-4 semester) threshold is met. Under this policy, 63% of students participate for more than one semester. The policy is relatively new, and the number of students participating for three or more semesters continues to increase.

In contrast to paid research experiences, **the VIP program is curricular, with students participating for letter grades**. This makes the program cost-effective, allowing faculty to take on the number of students needed, as opposed to the number of students they can support. The status of VIP as a curricular program also differentiates it from clubs and extracurricular activities. VIP students earn credits toward their degree requirements, engaging students who might not otherwise have time for extracurricular activities. The grading aspect holds students accountable for their performance, with letter grades maintaining a higher level of engagement than do pass/fail grades.

VIP projects are **long-term and large-scale**. The VIP model moves beyond the academic year model, with students participating for multiple semesters, projects lasting many years (even decades), and projects outlasting any single student. Projects are also large-scale, with ten to twenty students per VIP team. This ensures that enough students return each semester to maintain the continuity. Beyond being functionally important in team management, large team size creates student-to-faculty ratios that make the VIP model scalable in terms of students-served. With an average team size of 16 at Georgia Tech, once fully scaled, *every* student on a campus could participate in VIP. As VIP grows at each campus and as the VIP Consortium grows, we look forward to determining if this possible. The fact that this can even be considered makes the VIP Program unique in terms of its potential for systemic reform.

The key to VIP sustainability is long-term faculty engagement. Faculty stay engaged because: VIP gives them access to students both within and outside of their departments; teams make significant contributions to their research effort; and having a VIP team opens up new funding possibilities via the education, broader impact, and workforce development elements now required in many proposals. Annual release from teaching a regular course is not required to incent faculty to create teams – the additional capabilities that a team brings to faculty research efforts is sufficient. In some cases, teams contribute to ongoing research projects; in other cases, faculty use their VIP teams to test new ideas or delve into new areas in a low-risk setting. The idea of long-term faculty buy-in is demonstrated in Figure 1, which shows the longevity of VIP teams. While some teams have terminated, faculty members who get involved generally stay involved.

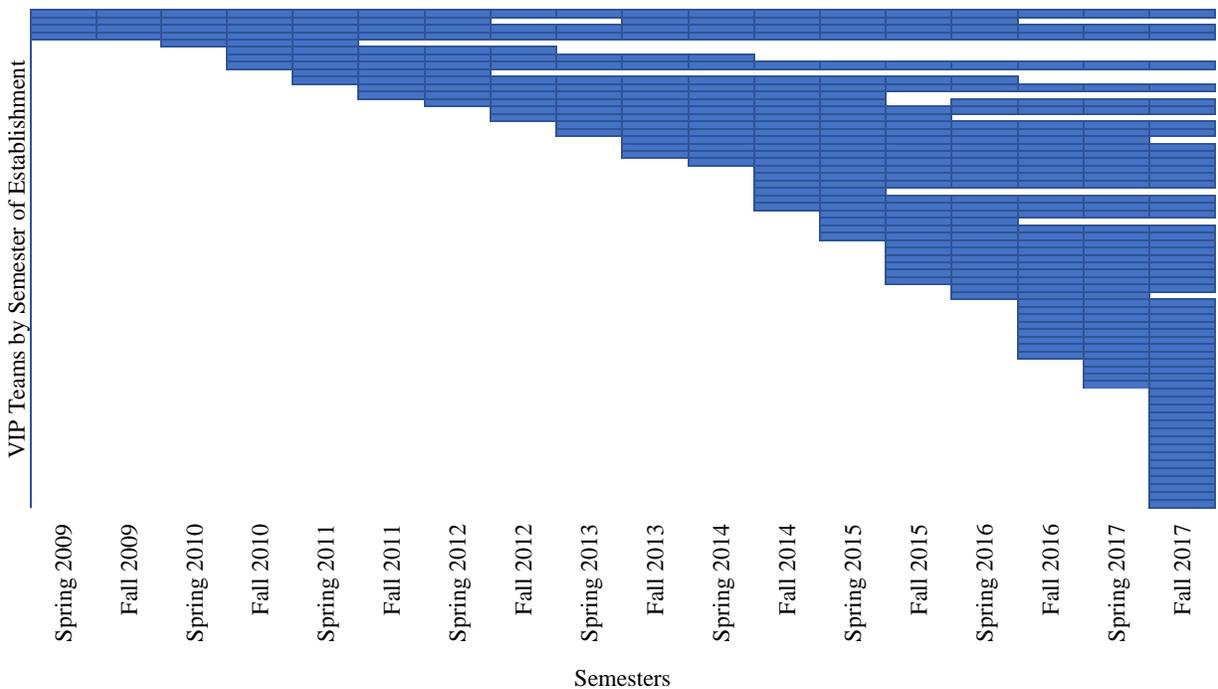


Figure 1. Georgia Tech VIP team longevity: team activity status by semester

Because VIP teams function more like research enterprises than courses, VIP teams need **dedicated, scheduled meeting spaces**. Team and subteam meetings are better suited to conference-style rooms that encourage face-to-face exchanges, as opposed to lecture-style classrooms. Dedicated meeting spaces allow VIP programs to schedule team meetings internally to accommodate instructor schedules, without having to deal with the campus-level scheduling system. The dedicated rooms support subteam meetings outside of regularly scheduled full-team meetings, which gives teams a home-base from which to work. Alternatively, some VIP teams meet in their faculty mentor's labs or departmental conference rooms.

While all current VIP Programs are multidisciplinary, the Consortium decided that **multidisciplinary teams are encouraged but not required**. Any large-scale, long-term project is by nature multidisciplinary, but the decision to not require multidisciplinary teams was based on two main factors. First, as a faculty-driven program, VIP sites typically begin as pilot programs led by one or two faculty members within a single department. The Consortium wanted to ensure that small, single-department pilot programs would still be recognized as VIP programs. Second, graduation requirements vary by institution, with some programs leaving little room for electives, either free or in-major. It is after seeing how well-functioning VIP teams benefit their students and faculty that departments typically adopt credit-use policies that allow VIP credits to count in meaningful ways toward degree requirements. Thus, the initial set of VIP teams in a new discipline must often be formed with students who are willing to participate even if their department's initial policies only allow VIP credits to count as free-electives. From the experiences of many VIP sites, a fraction of faculty and students will participate in VIP regardless of incentives. These early adopters then drive changes in their departments. Indeed, while one of the founding Consortium institutions anticipated being limited to a single department, the program at that institution has become multidisciplinary, attracting both students and instructors from other departments.

### *Aspects Supporting Diversity*

The traditional model of undergraduate research, in which select students are given the opportunity to work with faculty, is exclusive [10]. One-to-one faculty mentorship models cannot serve all students. Despite programs targeting historically underserved populations [1], the National Survey of Student Engagement indicates that historically underserved minorities, transfer students and first generation college students continue to participate in undergraduate research at lower rates [4]. There are typically two routes for students to secure undergraduate research opportunities: applying to competitive programs or approaching faculty, with both requiring a degree of confidence. Indeed, Science Magazine reported that Massachusetts Institute of Technology students need to approach five labs to find positions [11], and the American Psychological Association offers students guidance on overcoming this intimidating process [12].

By contrast, the vision of the VIP Program at Georgia Tech is to engage everyone on campus in innovation [13]. In this vision, every student can benefit from working with faculty on real projects, and every interested/willing faculty member can benefit from the efforts of their VIP teams. This philosophy shapes Georgia Tech's implementation of the VIP model, and students

see this difference in three primary ways: clearly presented opportunities; pro-active recruiting; and a lower intimidation factor.

Another route for undergraduate research experiences are course-based undergraduate research experiences, or CUREs. While VIP can be classified as a CURE [1], it does not carry the same overhead investment of course development and instructional time. Instead, it is more akin to traditional undergraduate research undertaken for academic credit during the school year, but in a team setting.

### Opportunities Clearly Presented

When students consider doing undergraduate research with faculty at their own university, they typically canvas faculty to find someone doing research in an area in which they are interested [11][12]. This may involve combing through faculty directories, webpages on technical interest groups within departments, and webpages for labs and centers on campus. Once faculty of interest are identified, the faculty may not be interested in working with the student [11][12]. In contrast, the Georgia Tech VIP Program maintains an online listing of VIP teams [14], with every team accepting new students every semester in order to replace students who graduate or leave the team. Additionally, every team is multidisciplinary, providing students with a broader range of projects than they might have found in their home departments. Team listings include overviews of team goals, methods, technologies, research/design issues, and narratives targeted at students. The online listings and student-oriented narratives make the program both welcoming and accessible.

### Proactive Recruiting

In addition to the online team listings, the VIP Program pro-actively recruits students across campus. Recruiting is done in two phases: prior to Phase I registration, during which students register for the upcoming semester, and during Phase II registration, which occurs immediately prior to and during the first week of classes. Recruiting consists of email campaigns, a poster information session in each registration phase, and targeted recruiting for low-enrollment teams during Phase II. For the email campaigns, the VIP Program obtains listings of undergraduate students by major and year in school. Email lists are constructed by major for students with (or approaching) sophomore rank or higher. Emails on the poster information session are sent to each list, addressing each group by major (Dear Computer Science Students, etc.). We found this yields a higher response rate, as students feel they are being personally solicited. Beyond generating attendance for the poster information sessions, which students may or may not attend, the email-blasts also yield an increase in applications.

The poster information sessions are held for one hour, with the midpoint coinciding with class dismissal and the start of another class block in the campus common schedule. This maximizes the number of students who can attend. Posters are presented by VIP students and advisors, and the sessions typically attract ~100 students. One session is held shortly before Phase I registration, when students are preparing to register for classes for the following semester. A second session is held on the Tuesday of the first week of class. The first session features as many teams as are interested/available, typically around 60% of teams. The second session only features low-enrollment teams, which helps them recruit more students. This smaller session is

helpful for teams that are sometimes out-shown by more “flashy” teams, but that are still appealing to students.

In addition to the second poster session, targeted recruiting is used to boost interest in lower-enrolled teams. For these teams, team advisors (instructors) identify courses that would be good feeders for the team. Class rosters for the previous year or two are pulled for those courses, and students receive emails explaining that the team is specifically looking for students who have taken the courses. These personalized invitations typically receive a positive response.

Together, these recruiting methods send a clear message to students that they are wanted. While this study does not assess whether this a contributor to representative enrollment in the program, it is a likely candidate.

#### Lower Intimidation Factor – First Come First Serve (Mostly)

In addition to proactively recruiting students, the Georgia Tech VIP Program offers a lower intimidation factor than competitive undergraduate research programs, or approaching individual faculty. As explained, students are able to browse available teams, knowing that teams accept new students every semester. Further, student selection is not based on grades, resumés, or interviews. The program has found little correlation between traditional screening criteria and successful team members – and the same observation has been made by Google [15], [16]. Instead of these traditional criteria, student selection is based on major and academic rank, to maintain a balance of different majors and different academic ranks (sophomores, juniors, etc.) on each team. Selection is partially on a first-come first-served basis, but a student from one major may be turned away if the team already has too many students from that major, while a student from another major may later be admitted. Similarly, a 2-credit student may be chosen over a 1-credit student of the same rank if the team is filling up. Automated messages to students who are not accepted explain that the team already has enough students from that major/year in school, and encourages them to apply to another team or to reapply for the same team earlier next semester. New instructors often question this method. To manage the transition, the VIP Director typically handles student selection in the first year or two for new teams. During this time, instructors come to realize that their best team members and team leaders do not necessarily have the highest GPAs, thus developing trust in this nontraditional admissions process.

While the selection process is not the first aspect of the program promoted to students, it is explained on the webpage. It is also reflected in the online application, which only requests student identity, major, year in school, requested team, number of credit hours (1 for sophomores, 1 or 2 for juniors and seniors, and 3 for Senior Design), and comments. The comment box is unassuming, and usually elicits a few sentences from students explaining why they’re interested. Unlike most research experiences, students do not have to write essays, fill out lengthy forms, or polish their resumes. Interested students apply and are accepted on a space available basis. Returning students are automatically accepted back onto their teams, and teams are marked “full” when no more space is available.

### Student Interaction within Teams by Race/Ethnicity

A previous study which relates to diversity examined student interactions within Georgia Tech VIP teams related to working in multidisciplinary teams and working with individuals from diverse backgrounds [17]. The study was motivated by analysis of institution exit surveys administered to graduating students, comparing responses for VIP participants and non-VIP participants. In the exit surveys, VIP participants reported statistically higher scores than non-participants, with meaningful effect sizes on three questions [18] :

To what degree did your Georgia Tech education contribute to your:

- Ability to work in a multidisciplinary team ( $t(1982) = 4.437, p < 0.001, d = 0.313$ );
- Ability to work with individuals from diverse backgrounds ( $t(1987) = 3.271, p = 0.001, d = 0.231$ );
- Understanding of technology applications relevant to your field of study ( $t(2002) = 3.19, p = 0.001, d = 0.224$ ). [18]

To study student interactions within teams that might contribute to students' ability to work in multidisciplinary teams and with individuals of diverse backgrounds, social network analysis was applied to student peer evaluations. Two metrics were used to analyze interactions: an EI index at the student level, which compares external (E) and internal (I) ties; and quadratic assignment procedure (QAP) analysis at the team level, which correlates interaction patterns within teams with member attributes, such as race/ethnicity. Whereas the EI indexes describe student experiences, the QAP analysis takes team composition into account. The results indicated that within VIP teams, students interacted more often with students of other races/ethnicities than their own, and more often with students from other majors than their own, as shown in Figure 2. QAP analysis indicated significant correlation between race/ethnicity and

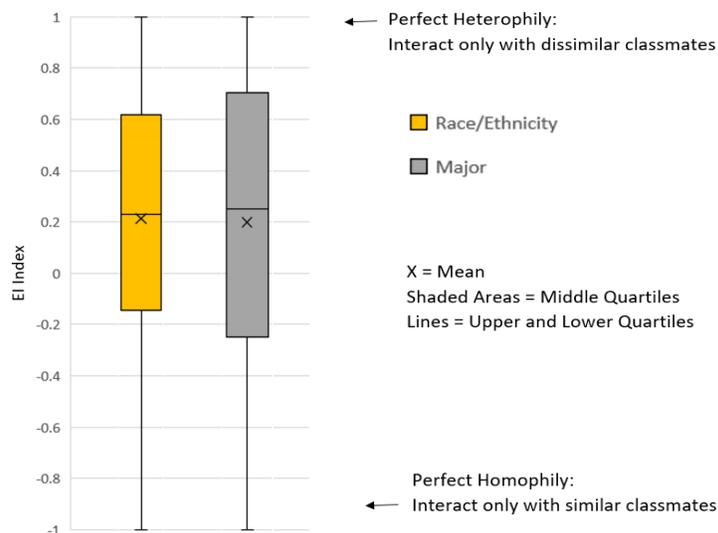


Figure 2. EI Indexes: Student interactions within and across categorizations

Note: Figure adapted from “Multidisciplinary Vertically Integrated Teams: Social Network Analysis of Peer Evaluations for Vertically Integrated Projects (VIP) Program Teams” [17].

student interaction (i.e. clumping by race/ethnicity) for one of the twenty-four teams. For student major, the analysis found significant correlation (i.e. clumping by major) for six of the twenty-four teams. To prevent “clumping” by race/ethnicity, which was found for one team, methods for establishing subteams around student technical interests are being incorporated into faculty professional development offerings.

### Georgia Tech VIP Enrollment and Persistence by Race/Ethnicity

Established in Spring 2009, the VIP program has been in place at Georgia Tech for nine years. The program started in the School of Electrical Engineering, but has evolved into a campus-wide program, drawing instructors from 27 departments and 6 non-degree granting units. The program now enrolls 900 students from nearly 30 majors and continues to grow (

Figure 3). In addition to a diversity of majors, the program enrolls representative proportions of black/African American students and Hispanic/Latino students, as shown in Figure 4, with proportionally lower participation for white students, and higher participation for Asian students. This study examined student persistence for students who first enrolled in the program between Spring 2009 and Fall 2015, allowing for at least four semesters of participation at the time of the analysis. For this reason, Fall 2015 was chosen to illustrate enrollment numbers by ethnicity.

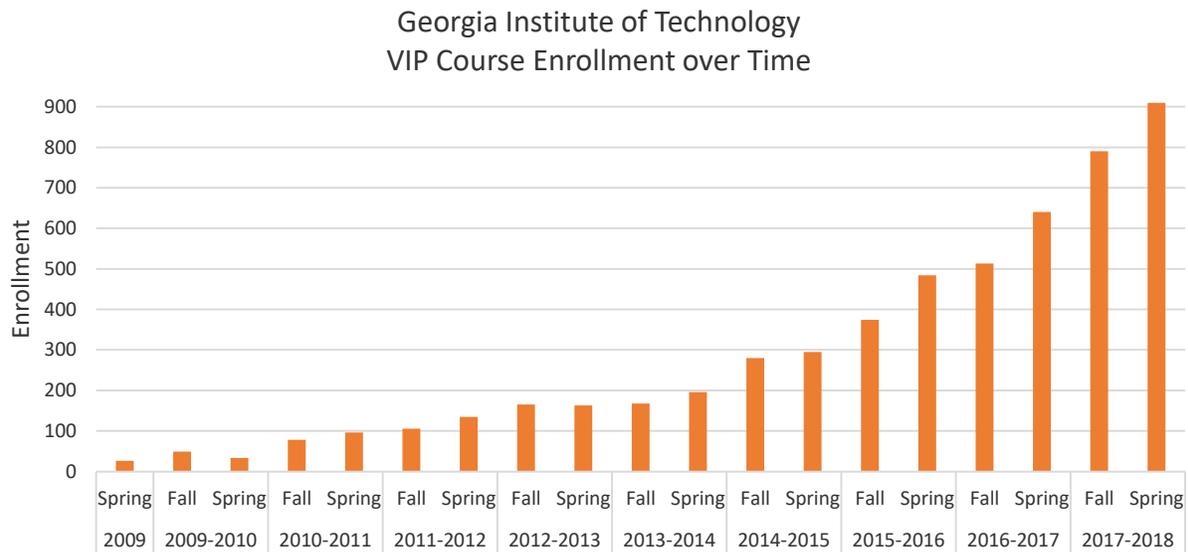


Figure 3. VIP enrollment over time at Georgia Tech

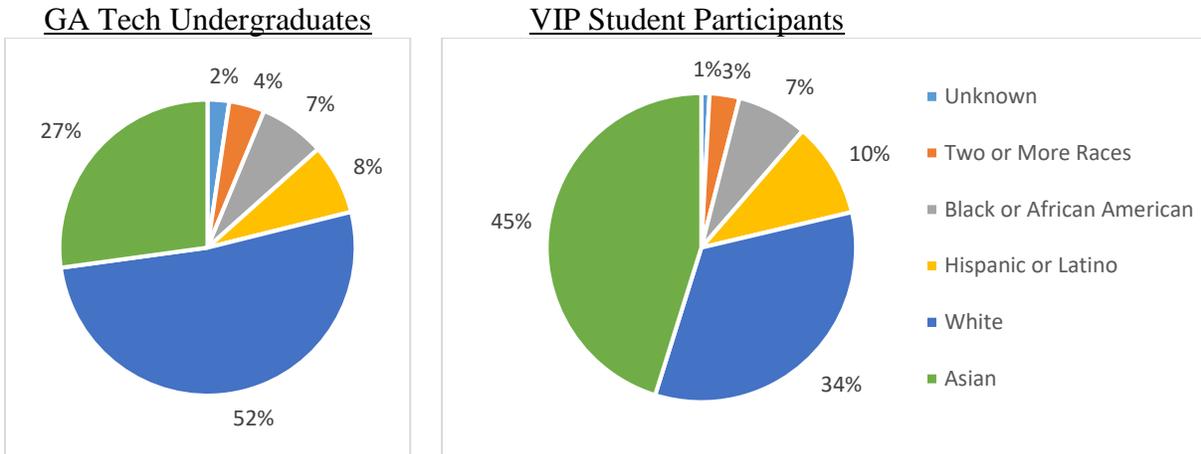


Figure 4. Demographics for Georgia Tech undergraduates and VIP students, Fall 2015

## Methods

To examine student persistence in VIP course sequence by race/ethnicity, student enrollment records were obtained for Spring 2009 through Spring 2017. In this context, student persistence describes the number of semesters a student participates in the VIP Program. The analysis was limited to students who first enrolled in VIP in Fall 2015 or prior, allowing at least three subsequent semesters for students to participate beyond their first term. This window was based on the premise of allowing students to participate in VIP for up to two years. To confirm the appropriateness of an analysis of variance, a test of homogeneity of variances was conducted. Analysis of variance was then used to compare persistence for students by race/ethnicity.

## Results

Levene's test for homogeneity of variances for persistence by race/ethnicity showed no significance,  $F(4,1251) = 1.596, p = .172$ , indicating an analysis of variance would be appropriate. Analysis of variance showed no significance for persistence by race/ethnicity,  $F(4, 1251) = 1.542, p = .188$ , indicating no relationship between race/ethnicity and the number of semesters students participated in the VIP program (Table 2), as illustrated in Figure 5.

Table 2. Analysis of Variance for Number of Semesters Enrolled in VIP by Race/Ethnicity, Spring 2009 through Fall 2015 Cohorts

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	6.434	4	1.608	1.542	.188
Within Groups	1304.973	1251	1.043		
Total	1311.407	1255			

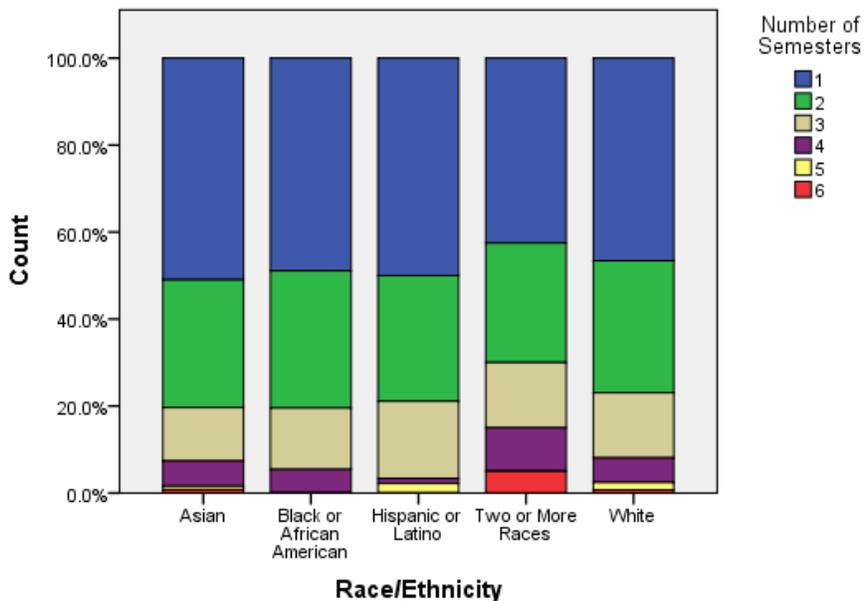


Figure 5. Student persistence in VIP by race/ethnicity, for students who first enrolled in VIP Spring 2009 through Fall 2015

## Discussion

The Georgia Tech VIP Program enrolls representative proportions of black/African American and Hispanic students as compared to the campus population, which runs contrary to national trends [4]. The program is designed to allow students to participate for at least two years, although students do not commit to participating multiple semesters. Analysis of variance showed students persist in course sequence at similar rates, with no differences for students by race/ethnicity.

While this study does not examine which aspects of the program contribute to these higher than average participation rates for historically underserved students, this paper profiled three main attributes that may contribute. First, opportunities are clearly communicated to students through accessible online team listings. Second, students are proactively recruited through email campaigns, poster information sessions and targeted recruiting. Third, the program has a lower intimidation factor, with a low-stress application, and with selection not based on GPA, resumes or interviews. These program attributes grow from the philosophy that all students can benefit from working on faculty-led teams that are focused on solving real problems, and that all willing/interested faculty can advance their research programs by working with VIP teams. Further work could be done to test whether these attributes contribute to equitable participation and persistence of underrepresented minorities, by comparing participation and persistence rates between VIP programs with different application and student selection processes.

## Works Cited

- [1] E. National Academies of Sciences, *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities*. 2017.
- [2] G. D. Kuh, “High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter,” Association of American Colleges and Universities, Sep. 2008.
- [3] Association of American Colleges and Universities, “High-Impact Practices,” *High Impact Practices*, 31-Oct-2013. [Online]. Available: <https://www.aacu.org/resources/high-impact-practices>. [Accessed: 28-Dec-2017].
- [4] National Survey of Student Engagement, “NSSE 2017 High-Impact Practices: U.S. Summary Percentages by Student Characteristics,” Indiana State University, 2017.
- [5] Association of American Colleges and Universities, “College learning for the new global century,” Association of American Colleges and Universities, Washington, DC, 2007.
- [6] VIP Consortium, “Beta version of the VIP Consortium website.” [Online]. Available: <http://consortium.vip.gatech.edu/>.
- [7] B. Aazhang *et al.*, “Vertically Integrated Projects (VIP) Programs: Multidisciplinary Projects with Homes in Any Discipline: American Society for Engineering Education,” presented at the 2017 ASEE Annual Conference and Exposition, Columbus, Ohio, 2017.
- [8] “How VIP Credits Count | VIP.” [Online]. Available: <http://www.vip.gatech.edu/how-vip-credits-count>. [Accessed: 06-Feb-2018].
- [9] J. Sonnenberg-Klein, R. T. Abler, and E. J. Coyle, “Correlation between Academic Credit-use Policies and Student Persistence in Vertically Integrated Project (VIP) Courses,” presented at the Manuscript submitted for publication, 2018.
- [10] S. H. Russell, M. P. Hancock, and J. McCullough, “Benefits of Undergraduate Research Experiences,” *Science*, vol. 316, no. 5824, pp. 548–549, 2007.
- [11] S. A. Webb, “The Importance of Undergraduate Research,” *Science / AAAS*, 06-Jul-2007. [Online]. Available: <http://www.sciencemag.org/careers/2007/07/importance-undergraduate-research>. [Accessed: 27-Dec-2017].
- [12] J. C. Norcross, “Getting involved in research as an undergraduate: nuts and bolts,” *American Psychological Association, Psychology Student Network*, Jan-2014. [Online]. Available: <http://www.apa.org/ed/precollege/psn/2014/01/research-undergraduate.aspx>. [Accessed: 27-Dec-2017].
- [13] E. J. Coyle, J. V. Krogmeier, R. T. Abler, A. Johnson, S. Marshall, and B. E. Gilchrist, “The Vertically-Integrated Projects (VIP) Program – Leveraging Faculty Research Interests to Transform Undergraduate STEM Education,” presented at the Transforming Institutions: 21st Century Undergraduate STEM Education Conference, 2014.
- [14] Georgia Institute of Technology VIP Program, “Vertically Integrated Projects Program, Georgia Institute of Technology,” *Vertically Integrated Projects Program, Georgia Institute of Technology*. [Online]. Available: [vip.gatech.edu](http://vip.gatech.edu).
- [15] A. Bryant, “In Head-Hunting, Big Data May Not Be Such a Big Deal,” *The New York Times*, 19-Jun-2013.
- [16] “Here’s Google’s Secret to Hiring the Best People,” *WIRED*. [Online]. Available: <https://www.wired.com/2015/04/hire-like-google/>. [Accessed: 29-Dec-2017].
- [17] J. Sonnenberg-Klein, R. T. Abler, E. J. Coyle, and H. H. Ai, “Multidisciplinary Vertically Integrated Teams: Social Network Analysis of Peer Evaluations for Vertically Integrated

Projects (VIP) Program Teams,” presented at the 2017 ASEE Annual Conference & Exposition, 2017.

- [18] J. Ludlum, “Georgia Tech Exit Survey Research Brief: VIP Program Comparisons,” Georgia Institute of Technology, 2015.