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STEM ACTIVE LEARNING VIGNETTE SERIES

## *Partnering for STEM Success*

### THE UNDERGRADUATE VIP PROGRAM AT VIRGINIA COMMONWEALTH UNIVERSITY

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PROMISE  
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CHANGE

## The Investment

Since beginning active grantmaking in 2008, the Leona M. and Harry B. Helmsley Charitable Trust (the Trust) has committed more than \$1.5 billion to nonprofits and other mission-aligned organizations in the United States and around the world. Although no longer a focus for the Trust, from 2008-2016 the Trust's postsecondary education grantmaking focused on increasing the number of college graduates in science, technology, engineering, and math (STEM) fields—particularly female students and students of color.

The Trust's postsecondary grantmaking portfolio supported networks of higher education institutions committed to improving instructional practices, primarily for gateway STEM courses, and creating incentives to adopt model policies, practices, and systems that can help improve student retention and completion. Each network adopted one or more active learning strategies, evidence-based teaching and learning approaches that can improve students' performance in STEM. While the Helmsley Charitable Trust's investment has concluded, most of the networks continue to move forward with implementing these strategies.

## The Evaluation

As the STEM Active Learning Networks evaluation and learning partner, Equal Measure is tracking the impact of the Helmsley Charitable Trust's postsecondary grantmaking on faculty, departmental, and institutional change across networks. Since 2014, Equal Measure has examined the conditions that support progress at the institution, department, and classroom levels toward network goals. Using qualitative methods, we have documented the results of network efforts, including emerging outcomes at the institution, department, and educator levels. In 2017, Equal Measure visited five campuses representing four of the initial seven networks to delve into site-level implementation.



## About Vertically Integrated Projects

Started at Purdue University in 2002 by Dr. Ed Coyle, now of the Georgia Institute of Technology (Georgia Tech), the Vertically Integrated Projects (VIP)<sup>1</sup> program focuses on student persistence in STEM majors through the incorporation of active learning techniques. VIP program courses, today at 18 colleges and universities, integrate undergraduate education and faculty research in a team-based context. In addition, the program is multidisciplinary, and attracts students from schools and departments across the campuses of each participating institution.

The design of VIP arose from concerns about how academic disciplines are siloed at many higher education institutions, and that this structure does not enhance the undergraduate experience. VIP students earn academic credits in their major for up to three years, and receive hands-on research experience while developing leadership skills and experiencing different roles on large multidisciplinary design/discovery teams. In the VIP course, there are no time constraints on completing a project, so students can devote more time to research and different aspects of experiential learning. VIP faculty and graduate students benefit from the design and discovery efforts of their teams by having a cadre of eager, engaged undergraduate students contribute to the faculty member's research projects. The long-term nature of VIP creates a mentoring environment with faculty and graduate students, with experienced undergraduate students mentoring newly enrolled undergraduates, and with students moving into leadership roles as others graduate. VIP also allows businesses to invest in the various design/discovery teams.

In 2015, VIP (through Dr. Ed Coyle and his team) received Trust funding to expand beyond its original four U.S. institutions (Georgia Tech, the University of Michigan, Purdue University, and Texas A&M) to an additional 12 schools,<sup>2</sup> and to create a VIP Consortium and an annual Consortium-wide conference. The Trust funding also enabled the VIP Consortium to conduct a Consortium-wide evaluation focused on how well students learn to: 1) integrate and refine the knowledge and skills they gain through coursework with what they learn through VIP; and 2) work effectively in student-led, multi-generational, and multi-disciplinary teams.<sup>3</sup>

### THE FOLLOWING INSTITUTIONS ARE PART OF THE VIP CONSORTIUM:\*

#### Original Institutions

Georgia Institute of Technology, Atlanta, GA  
 Purdue University, West Lafayette, IN  
 Texas A&M University, College Station, TX  
 University of Michigan, Ann Arbor, MI  
 University of Strathclyde, Glasgow, Scotland, UK  
 National Ilan University, Ilan, Taiwan

#### Started in 2015 as part of Helmsley Trust funding:

Morehouse College, Atlanta, GA  
 University of Washington, Seattle, WA  
 Florida International University, Miami, FL  
 University of California - Davis, Davis, CA  
 Howard University, Washington, DC  
 Colorado State University, Fort Collins, CO  
 Virginia Commonwealth University, Richmond, VA  
 University of Hawaii - Manoa, Honolulu, HI  
 Indiana University, Maurer School of Law, Bloomington, IN  
 Boise State University, Boise, ID  
 Rice University, Houston, TX  
 University of Delaware, Newark, DE

\*VIP continues to scale to other institutions within the U.S. and abroad.



*“One of the big strengths of the VIP Consortium is that schools can share experiences with a diverse set of respected institutions, and institutions can ask questions about, ‘How is something going to work? How do you get a department to give credit? How do I get the team up and running?’”*

-VIP CONSORTIUM MEMBER

## ABOUT VIRGINIA COMMONWEALTH UNIVERSITY



Located in Richmond, VA, Virginia Commonwealth University (VCU) is an urban, public research university with more than 30,000 students. The VCU College of Engineering was one of the 10 VIP Consortium partners funded through the Trust’s postsecondary investment. VCU’s College of Engineering was founded in 1996 as a public-private partnership. At that time, VCU was one of the only major universities in a U.S. state capitol that did not have an engineering school.

Leaders from government, industry, and academia established the College of Engineering Foundation<sup>4</sup> and supported construction of two campus buildings to house the College of Engineering. The college continues to grow on campus with new construction. The College of Engineering has five departments: Biomedical Engineering, Chemical and Life Science Engineering, Computer Science, Electrical and Computer Engineering, and Mechanical and Nuclear Engineering.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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**2002**  
**VIP created at Purdue University**

**2008**  
**VIP begins at Georgia Tech**

**2015**  
**VIP begins at VCU**



An early champion of the VIP program at VCU, Dr. Robert Klenke, a professor of electrical and computer engineering, saw the value of this model through his experience working with undergraduates. Many of his students participated in project-based and team-learning courses—

for instance, the Association for Unmanned Vehicle Systems International’s Student Unmanned Aerial Systems Competition, which requires teams of students to design, build, and fly drones as part of the competition.

Through entering student teams in this competition for many years, Dr. Klenke found that with each new cohort of students, their learning curve was similar, and there was no continuity or institutional memory from one year to the next. Prior to VIP, seniors would typically participate in the competition and then graduate. Dr. Klenke considered VIP a greater opportunity for his students to excel in this competition by providing a curricular structure/mechanism or model to support them over continuous semesters. He also saw VIP as an opportunity to deepen a student’s undergraduate research experience. Dr. Klenke now serves as director of the VIP program at VCU.

VCU piloted a soft launch of VIP in spring 2015, and set up five VIP teams during the following academic year. Currently, faculty and students from each College of Engineering department participate in VIP. There are also nursing and biology students engaged in VIP teams, as well as students from the School of the Arts. At the time of our visit in 2017, there were 12 VIP teams, with some faculty members leading multiple VIP courses. The largest VIP team had 45 students.

**VCU VIP teams include:**

- Collaborative Unmanned Aerial Vehicles
- Engineering Critical Patient Care Team
- Bone Marrow Transplant Team
- Medical Device Development and Prototyping
- Nanoinformatics
- MechanoUrology
- Aerosol-Enabled Nanomaterials Synthesis
- Characterization & Applications
- Sustain Lab
- 4D Printing and Beyond
- Formula SAE at VCU
- Optics and Photonics
- Hyperloop at VCU



Students are informed about VIP (referred to as ENGR 497 in the course guide) through e-mails, information fairs, word of mouth, and other methods. Students may receive one or two credits for the course each semester.<sup>5</sup> Each VIP project team receives \$10,000 at the start of the team to use as unrestricted funds (e.g., toward purchasing materials for the project, like software or a computer, going on trips, etc).

An Electrical & Computer Engineering graduate student provides administrative support to the VIP teams (e.g., assisting with grading rubrics and peer evaluations). Having the graduate student assist with the administrative launch, including grading requirements and course expectations, is critical. Students are graded based on peer evaluations, reviews of logged efforts in their VIP notebooks, and submissions to a VIP Wiki log, where teams collaborate to create, share, and discuss files, ideas, minutes, specs, mockups, diagrams, and projects.

*VIP also bridges the gap between pure research and industrial partnerships. About five to ten percent of our students are going to go to grad school. Maybe we're getting those kids invested in research using intensive pure research experiences. We are also providing industry experiences, and talking about partnerships with industry.*

-VCU COLLEGE OF ENGINEERING FACULTY MEMBER AND VIP FACULTY MENTOR

## HOW ONE VIP TEAM TACKLES HUMAN ERROR

The Department of Anesthesiology at VCU approached an engineering professor to attend a meeting, during which several Anesthesiology faculty sought help to address logistical problems they were facing in operating rooms, including issues of ergonomics, work flow, and other challenges that could lead to human error and affect patient safety. The engineering professor, Dr. Bennett Ward, took the challenges discussed during this meeting and started his own VIP team. The team started out small, with about five students, and over two years has grown to include more than 20 students and faculty each semester from several departments and schools, including biology, chemistry, environmental studies, the School of the Arts, the School of Business, and the School of Nursing. This Engineering Critical Care VIP team works on multiple projects at once.

The VIP team has worked on several projects to improve the work environment for anesthesiologists, technicians, and nurses, including: how to reduce dosing errors with an app (a patent has been filed for this project); how to design pressure-sensing epidural needles; how to help surgeons remember to take a central line out of a person's artery; and how to keep surgical instrument trays sterilized. The team has developed prototypes of various products that hospitals could use.

The art students assist with designing the products and making the products user-friendly. The business school students create business plans for how to license these products and pitch them to industry. The entrepreneurial-minded faculty advisor hopes the team can license the technology to a company to develop and market the product, as a step toward funding future VIP teams.

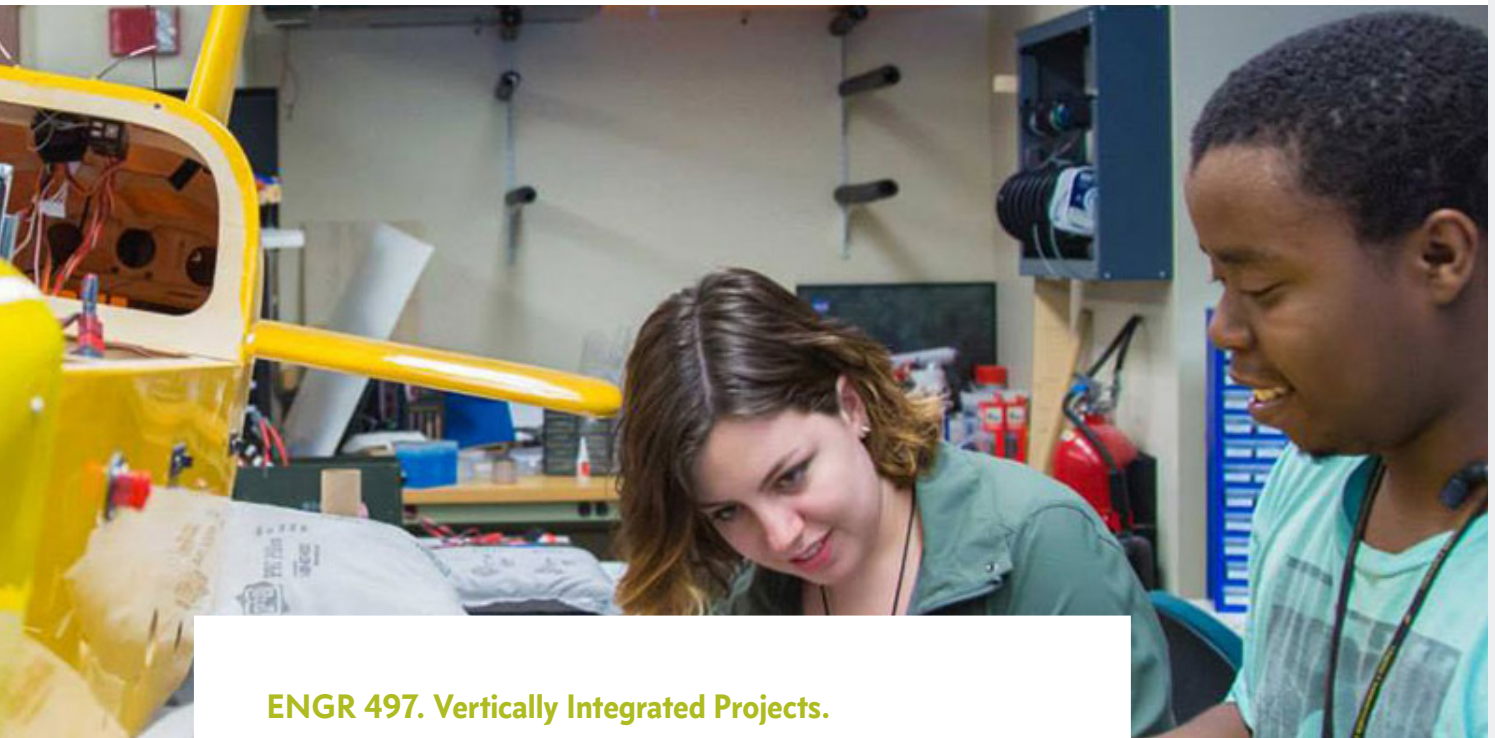


## VIP Serves as a Catalyst for Increased Student Learning in STEM

Undergraduate research experiences contribute to student persistence in STEM, and undergraduate research is recognized as a high impact practice.<sup>6</sup> Faculty interviewed throughout the College of Engineering spoke to the impact of VIP on students, including how VIP exposes undergraduates much earlier to research opportunities, strengthens their research skills, and sharpens their teamwork and project leadership skills. Faculty described seeing students' confidence increase in assuming leadership roles on a project and presenting findings in front of classmates. The VIP model also requires faculty to engage with students differently, and catalyzes professors to become more creative in how they include undergraduates in their research. By working with students in this manner, student learning in STEM increases and students tend to persist in their STEM majors.<sup>7</sup>

VIP has also assisted in deepening partnerships between the College of Engineering and local employers. These relationships are critical because VIP teams can play a lead role in developing products for these businesses and students can gain valuable research and design experience. These employer-university partnerships may also inspire businesses to donate resources to the schools and hire graduates (both outcomes are occurring at VCU).





### **ENGR 497. Vertically Integrated Projects.**

Semester course; 3 or 6 laboratory hours. 1 or 2 credits.  
May be repeated for a maximum total of 8 credits.

**Prerequisites:** permission of the project faculty adviser.

This course provides undergraduate students the opportunity to participate in multiyear, multidisciplinary projects under the guidance of faculty and graduate students in their areas of expertise. As they address research and development issues, students learn and practice many different professional skills, make substantial technical contributions to the project, and experience many different roles on a large, multidisciplinary design/discovery team. Students must earn a minimum of 4 credits in ENGR 497 with a minimum grade of C in order for these credits to be eligible to count toward a technical or departmental elective. More restrictive requirements may be imposed by individual departments.

—From <http://bulletin.vcu.edu/azcourses/engr/>





▶ **Administrators and participating professors at the VCU College of Engineering see great value in the VIP program which engages students in research, advances faculty research, and strengthens industry partnerships between employers and the school.**

These partnerships, along with contributions from entrepreneurially driven faculty members, will help sustain VIP at VCU past the Trust funding. There is strong leadership and advocacy within the College of Engineering for this type of undergraduate research and teaching. For instance, College of Engineering Dean Dr. Barbara Boyan considers VIP *“the most innovative teaching on campus.”* Faculty and administrators who previously worked in the business sector are motivated to conduct research and development projects as VIP teams. Because VIP requires a significant investment of time, it is important that VIP is led by faculty members who find value in the program.

▶ **The College of Engineering is identifying opportunities to institutionalize VIP at VCU.**

Altria, the parent company of Phillip Morris USA, headquartered in Richmond, VA, created a \$500,000 endowment when the College of Engineering opened. Altria initially targeted funds from the endowment to develop programs that integrate engineering and business. Executive Associate Dean Franklin Bost discussed with Altria the opportunity to repurpose the endowment to support VIP. Officials from Altria expressed strong enthusiasm for the VIP projects and allowed the college to repurpose the endowment, which currently stands at \$1 million. Now the College of Engineering can continue to provide new VIP faculty mentors with an initial \$10,000 budget.

▶ **Faculty spoke of the potential to tie VIP to the senior Capstone projects.<sup>8</sup>**

The VCU director of Capstone projects also serves as a faculty mentor for a VIP team. With VIP, there is an opportunity to work with sophomores and juniors on projects that evolve into Capstone projects by their senior year; thus, the student becomes more deeply involved in the project research and more knowledgeable about the subject. More than half of the Capstone projects come from industry—for example, Newport Shipbuilding, Pfizer, Capital One, and General Electric—and by incorporating these projects into VIP, there may be even more opportunities to deepen the College’s partnerships with local industry leaders.



As evidenced with VCU, rolling out a new national initiative—like VIP—to various colleges and universities requires substantial coordination within a department or school at various levels of leadership and from different partners. For those who want to scale a practice within their institution or to other institutions, a few points must be considered:

**1 Start with an external champion and a network of supporters.**

Through Dr. Ed Coyle’s large network, and through the VIP Consortium of schools, VIP has been championed and spread to other campuses. And departmental leaders who are part of the VIP Consortium have played an important role in supporting and scaling this program within their schools and departments, as well as to other universities, by speaking about VIP at conferences and annual meetings and hosting visits from interested faculty.

**2 Place a strong focus on logistics and fidelity to implementation.**

From the beginning of the scaling of VIP at VCU, there was a strong emphasis on the “nuts and bolts” of implementation, including sequencing course numbers, setting up VIP teams, recruiting students, conducting student assessments, and tracking—with a substantial showcasing of Georgia Tech VIP approaches from Dr. Coyle’s team.

**3 Emphasize cross-institution and interdisciplinary learning.**

The Consortium provides critical implementation support to VIP institutions. Consortium members share implementation lessons to deepen collective knowledge about promising VIP approaches, networking, building one-on-one and consortium-wide connections, and learning from one another.



Georgia Kioukis and Ray McGhee of Equal Measure conducted the site visit with Virginia Commonwealth University and would like to thank the following interviewees from VCU's College of Engineering who participated:

- L. Franklin Bost, MBA, IDSA, FAIMBE, Executive Associate Dean for Innovation and Outreach, Director of the VCU Institute for Engineering and Medicine and Professor in the Department of Mechanical and Nuclear Engineering
- Barbara D. Boyan, PhD, Alice T. and William H. Goodwin Jr. Chair, Dean of the VCU College of Engineering and Professor in the Department of Biomedical Engineering
- Afroditi V. Filippas, PhD, Associate Dean for Undergraduate Studies; Professor, Department of Electrical and Computer Engineering
- Stephen S. Fong, PhD, Associate Professor and Vice Chair, and Director of Undergraduate Programs, Department of Chemical and Life Science Engineering
- Nathaniel Kinsey, PhD, Assistant Professor, Department of Electrical and Computer Engineering
- Robert H. Klenke, PhD, Professor, Department of Electrical and Computer Engineering; Director, Vertically Integrated Projects Program
- Matt Leccadito, Graduate Research Assistant, Department of Electrical and Computer Engineering
- Bridget McInnes, PhD, Assistant Professor, Department of Computer Science
- Erdem Topsakal, PhD, Professor and Chair, Department of Electrical and Computer Engineering
- Bennett (Ben) Ward, PhD, Director of Project Outreach, Associate Professor

We also thank Dr. Ed Coyle of Georgia Tech University, who participated in phone interviews prior to the site visit.



- 1 Learn more about the VIP Program: <http://www.vip.gaTech.edu/>
- 2 These institutions were Boise State University, Colorado State University, Florida International University, Howard University, Morehouse College, Rice University, University of California-Davis, University of Hawaii, University of Strathclyde, Virginia Commonwealth University.
- 3 Learn more about knowledge exchange in VIP Project teams:  
<http://www.vip.gatech.edu/sites/default/files/about%20vip%20-%20evaluation.pdf>
- 4 Learn more about the VCU College of Engineering Foundation: <https://egr.vcu.edu/giving/foundation/>
- 5 Each department within the College of Engineering has a different requirement for how they count technical credits. The ENGR 497 course had to get approved by the college undergraduate curriculum committee and the university undergraduate curriculum committee.
- 6 Undergraduate Research as a High-Impact Student Experience:  
<https://www.aacu.org/publications-research/periodicals/undergraduate-research-high-impact-student-experience>
- 7 Linking Evidence and Promising Practices in Science, Technology, Engineering, and Mathematics - A Status Report for The National Academies National Research Council Board of Science Education:  
[http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse\\_072637.pdf](http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072637.pdf)
- 8 The Capstone Design course at the VCU College of Engineering is considered the climax of every engineering student's undergraduate education. As a prerequisite to attaining a Bachelor's degree, the Capstone Design course presents each student with the challenge of working in a team to tackle actual engineering problems within and across the fields of Chemical and Life Science, Mechanical and Nuclear, Biomedical, Electrical, and Computer Engineering and Science. <https://egr.vcu.edu/capstone/>

