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Board 314: Implementing the Vertically Integrated Projects (VIP) Model at a Public Urban Research University in the Southeastern United States

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Implementing the Vertically Integrated Projects (VIP) Model at a Public Urban Research University in the Southeastern United States

Underproduction, low retention, and lack of diversity in STEM disciplines, especially engineering, are significant challenges nationally, but are particularly acute in regions, both urban and rural, where educational access is limited. Leveraging our institutional location at a public urban research university in a city marked by its connection to its rural surroundings, we seek to address these challenges by implementing the Vertically Integrated Projects (VIP) model at our university with the support of an NSF IUSE grant. The VIP model is based on active learning and enables tiered mentoring from students at all academic years, thereby providing the opportunity of role modeling from upper-level undergraduate and graduate students as well as faculty. In addition, programs based on the VIP model are accessible to all students (not just high performing students) and provide a meaningful networking environment. We use our implementation of the VIP model to foster STEM identity growth and a sense of belonging, while increasing and celebrating diversity in engineering and other STEM disciplines.

The purpose of this paper is to report on the planning and launch of the VIP program at the University of Memphis (UofM) in Fall 2022, focusing on the PIs' experiences implementing the program and on our first cohort's (N = 12; 7 women; 4 Black/African American; 2 Hispanic) experiences participating in the program during its first semester. Specifically, this paper will describe the challenges and opportunities of implementing the VIP program and how the VIP model has been adapted to align with unique aspects of our institution and student body. We will also report preliminary analyses of student journal data collected from the first cohort throughout the Fall semester, where students described their initial expectations/hopes and concerns for the semester; their activities and emotional responses during the semester; and finally, their reflections on their experiences, positive or negative, throughout the semester. The paper will conclude by offering lessons learned from the first year of this project as well as directions for moving forward.

Literature Review

The Vertically-Integrated Projects (VIP) model [1-4] engages students in multi-scale, long-term research project teams led by faculty and their graduate students. The VIP teams comprise undergraduate and graduate students at different stages of their studies, and all participating students are graded and receive credit toward their degree for at least two years. Students choose from a wide variety of VIP teams based on personal interest. Participation in VIP teams provides the time and context for students to [5]:
- acquire in-depth experience and insights within their field of study;
- learn and practice research and professional skills;
- make substantial contributions to real-world projects; and
- experience different roles on large, multi-disciplinary teams.

The VIP structure provides opportunities for students to develop leadership and collaboration skills through peer support and peer management, which provide students with accountability [6, 7]. Faculty engage in the program because VIP teams support the work of their graduate students, advancing their scholarship and research.

The VIP model [8] has evolved over the decades and has been adopted by dozens of universities of varying sizes and levels of research activity [9]. One study has shown that when the VIP program was accessible to all students, it helped increase diversity (race/ethnicity) in undergraduate research [10] perhaps owing to recruiting applicants broadly and selecting participants based on a low-stress application rather than GPA, resumes or interviews.

In summary, programs based on the VIP model can have a positive effect on student learning outcomes, diversity and accessibility, and 21st century workforce preparedness, and can help increase the pipeline for advanced degrees. VIP Programs can be established successfully by either faculty who pilot a few teams under temporary course numbers, or by college deans and university presidents. VIP programs can gradually expand to multiple departments and serve students from many majors within the interdisciplinary nature of the VIP model. Key requirements for a VIP program are the curricular structure that allows students to earn credit and meeting spaces that enable teamwork (e.g., conference room or class with modular furniture, or faculty research laboratory). Many sites begin with temporary course numbers, either from a single department, the college, or the university to first pilot the VIP program.

The UofM Model

Our VIP program leverages these best practices from the well-established VIP model and adapts it to address unique aspects of our university's community and interests. Specifically, the program includes first-year students and focuses especially on building an inclusive research culture within the college. It employs a tiered mentoring approach and activities that prepare students for research and foster networking. The long-term goal of the VIP experience is to create a research culture and community in engineering, and eventually across STEM disciplines, that is inclusive and supportive of students from diverse backgrounds. An additional focus is to showcase the value of diversity in research and innovation through the program. Both the research culture and increased acknowledgement of the value of diversity are designed to enhance students' STEM identity, which is important for retention in the major and career.
The UofM VIP program includes the following:
- A sequence of 1-hour VIP courses open to all engineering students from first-year (Honors students only) to seniors (all engineering students); a three-semester enrollment yields credit for a technical elective (see Figure 1);
- Students apply to join a specific research team led by a UofM faculty member; while not encouraged, students are allowed to switch teams after the first semester, but must sit out of the program for a semester if they desire to change teams a second time;
- A tiered mentoring program of graduate students, upper division, and lower division undergraduates with a formal mentoring training program for graduate students and undergraduate mentors;
- Research and career exploration seminars with industry and academic researchers, and
- Opportunities to continue research during the summer in paid undergraduate research assistant positions.

Our research is focused on understanding how the VIP program at the UofM impacts students' engineering/STEM identity, self-efficacy, growth mindset, persistence, and academic success. We are also exploring the program's impact on the culture of inclusion in the college of

engineering. Finally, through our study and iteration of the program, we plan to identify determinants for a scalable and sustainable model at the UofM.

VIP: Vertically Integrated Projects

Students work in vertically integrated projects (VIP) teams on interdisciplinary faculty-lead research. VIP team members range from freshmen through graduate students, from first-time participants to students who have been involved for three or more semesters. Individual members work on different aspects of the research project. It is expected that students will enroll in progressive VIP courses for *three consecutive semesters* and participate at the appropriate level of experience to earn 3.0 hours of credit.

ENGR 1211 - Exploration
This course is intended for introductory team members; students are expected to maintain involvement with the same project team for multiple terms. This course satisfies the Honors Forum UNHP 1100.

ENGR 2211 - Introductory
This course is intended for introductory team members; students are expected to maintain involvement with the same project team for multiple terms.

ENGR 3211 - Intermediate
This course is intended for intermediate team members or students who have working knowledge of the project topic.

ENGR 4211 - Advanced
This course is intended for advanced team members with two or more semesters of experience on the same project.
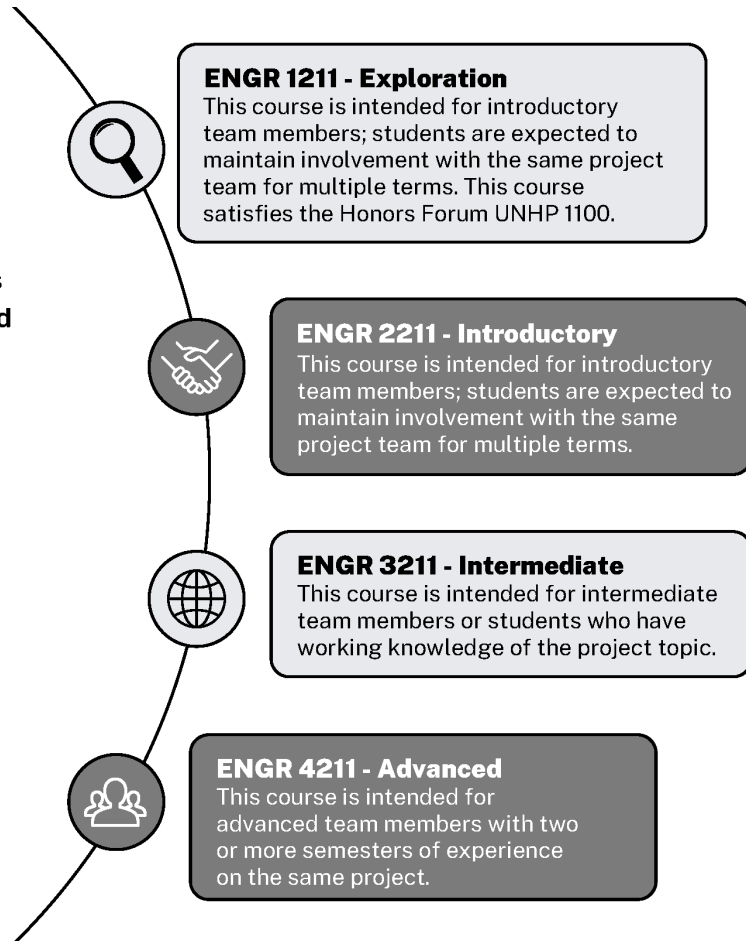
Figure 1. Description of Course Sequence for VIP Courses

Fall 2022 Pilot

We started our VIP program with two teams, led by the project PIs, formed in August 2022, as part of a pilot study. One team was led by a faculty in electrical and computer engineering with a research focus on improving microscopes using computational imaging enabled by deep learning. This VIP team was guided by two graduate students and the faculty member, and it included 7 undergraduate students (3 women, 4 Black/African American, and 2 Hispanic): 2 first-years, 2 sophomore and 1 senior in computer engineering; 1 junior in mechanical engineering; and 1 junior in biomedical engineering. The second VIP team was led by a faculty in civil engineering and focused on research in integrating social media and public data in assessment of community livability. The team was guided by three graduate students and the faculty member, and it included 5 undergraduate students (4 women and 1 Black/African American): 2 first-years, 1 junior, and 1 senior in civil engineering; and 1 senior in computer and electrical engineering. Students were recruited through email invitations that were sent to all students in the college as well as through info sessions held in person and via Zoom.

Recruitment for the Fall 2022 cohort began in the previous spring. Students applied to the program through an online application and were accepted if there was room on the team.

Results

Semester Deliverables

While the UofM VIP program is flexible to students' interests and capabilities, a formal set of deliverables is required so that students demonstrate their accomplishments – both individually and within their team. For the Fall 2022 semester, each team prepared a report that was submitted at the end of the semester that summarized research activities and results. The report was prepared in a format such that it became a working manuscript, with the ultimate goal being a conference or journal submission once enough data has been gathered/analyzed and results documented by the team. The timing of such a submission is dependent upon the particular research tasks the students are engaged in and the level of experience and time commitment the students have to the team. The first cohort had one subteam that submitted a completed paper to the UofM's undergraduate research journal. A second subteam had a draft paper but did not complete it in time for the journal's submission deadline. The second team has a working paper that may be built upon in future semesters. Additionally, each team prepared a presentation at the end of each semester that summarized their experience, highlighted individual and team accomplishments, and shared what the team learned. Students were also required to submit two peer reviews, one at mid-semester and one at the end of the semester. Most students were complimentary of their peers, although there was some indication that a few of the students were not contributing as much as their teammates expected.

Journal Data

Students wrote weekly journals throughout the semester. Here we present a preliminary analysis of their first and last week's journals from the fall semester, to show what students' expectations were at the outset and how they described their experiences at the end of the semester. We will present a more formal analysis of the journals from the fall and spring semesters in a future paper. Most responses to each prompt were brief, typically one sentence and rarely more than three.

In the first week, students responded to the following prompts: "What are your expectations for your experience in the VIP program? What do you hope to learn or gain from the program?"; "What are you most looking forward to doing as part of the VIP program?"; and "What are you most nervous or concerned about the VIP program?" In response to the first two prompts, most students' responses focused on gaining research experience and skills through the program, as well as learning specific knowledge about the project they were on. For example, one student responded:

I'm looking forward to doing the work, especially the coding, and contributing with the other skills I have to the research. The research I am part of involves the understanding of optics; it is something I have delved into, but I would love to learn more about it.

Other responses highlighted the collaborative and group-based aspects of the experience, working with other students, graduate students, and faculty.

The third prompt asked students what they were most nervous or concerned about regarding the VIP program. These responses tended to focus on their current level of knowledge or skill and/or whether they would be able to contribute or work well with their team. For example, one student stated, "I am most worried that my unfamiliarity with the subject matter will cause me to be 'dead weight' to the team."

At the end of the semester, students were asked to describe their overall feelings about the VIP program as well as their most positive and negative experiences in the program. Overall, students had positive feelings about the program. Their positive experiences were focused on collaboration, especially with graduate students and students from various engineering backgrounds, as well their hands-on research experience and working on a paper. However, many students felt there was not enough time in the course for research and writing. Other negative experiences included feeling they did not understand the purpose of assignments on the course learning management system and other team members were not contributing. At the beginning of the semester, assignments focused on ethics, teaming, how to do a literature review and document research, and other preliminary topics. Students wanted to dive right into the research rather than completing training and pre-research activities. Additionally, journal assignments requested that students reflect on their experiences weekly. Engineering students are not accustomed to assignments that ask about their feelings and emotional responses, which confused some of the students. To address this, the faculty now explain that the self-reflection is intended to not only help them gain more out of the experience, but also to help faculty understand what works well and what does not so that the program can be altered to better suit student needs and expectations. Faculty also are emphasizing more heavily the value of the pre-work in preparing students for research success.

Overall, these preliminary findings suggest that VIP participants came into the program looking forward to working on research projects and gaining research skills and to working with other students. These expectations generally matched their experiences during the semester. However, students were disappointed in the amount of time spent directly on research and did not see the relationship between what they were doing early in the course and the final research project.

Mentoring

Five graduate students participated in the fall 2022 semester as mentors to the undergraduate VIP students (two for one team, three for the other). The graduate students also participated in a series of a mentoring workshop with the lead faculty members for the teams (PI and co-PI on the project). The graduate students were asked to be part of the program but were not told they would receive a stipend at the end of the semester for the extra effort that would be required to support the VIP teams. All of the graduate students that were invited to participate agreed to do so, resulting in more graduate students than expected for the VIP program. The graduate students took their roles as mentors very seriously, and all contributed more time than was expected by the faculty to the program. They also indicated that they really enjoyed the opportunity to serve as mentors – several even requesting to be included in subsequent semesters before the fall semester ended. All of the graduate students were retained in the program for the spring 2023 semester.

Student retention

From the initial 12 students that participated in the fall 2022 pilot program, 5 students (4 women, 1 Black/African American, and 1 Hispanic) did not continue to the spring 2023 semester. Three of these students were first-years, while the others were a junior and a senior. Two of them (Black/African American and Hispanic) indicated that, although they enjoyed the VIP experience, they were too busy with other courses and work and could not continue.

Challenges and Lessons Learned

Retention Issues

One key challenge we faced in implementing the program was in retention of students to the second semester. There were two key sets of students for whom retention was particularly challenging: first-year and civil engineering students. First-year students that were eligible for VIP were those in the Honors program at the UofM. All Honors first-year students are required to take a 1-hour Honors Forum course. The VIP course could substitute for this requirement for first-year honors students. We found that the first-year students who enrolled in the VIP course were primarily interested in obtaining credit for the Honors Forum and not necessarily committed to continuing in the VIP team.

For civil engineering students, the department does not allow credit through the VIP course sequence but rather through an alternative projects course that was already part of the civil engineering curriculum. One civil engineering student that was enrolled in the Fall semester had already taken the projects course (and thus, could not earn credit toward the degree for taking it a second time for the VIP program). While she was interested in the research experience and served in a leadership role for her team, she was not able to commit the time (or cost for an unapplied elective) required to continue VIP in subsequent semesters. In future semesters, we hope to address these issues by hosting information sessions that target first-year students earlier in the summer so that students better understand VIP and the commitment to the research experience. Similarly, as civil engineering students become aware of the VIP opportunity earlier in their degree programs, we anticipate that they will be able to make informed decisions regarding the civil engineering projects course so that they can choose the VIP course to satisfy this requirement.

Curricular Development

The VIP courses were introduced as special topic courses at four levels initially designated for first-years, sophomores, juniors, and seniors in the college of engineering with an ENGR prefix, so that students from any department could register. For subsequent semester offerings the four course levels will be designated as: exploratory (for first-years), introductory (for students taking a VIP course of the first time), intermediate (for students taking a VIP course for the second time) and advanced (for students that have completed two semesters of the VIP course). Three departments in the college of engineering (biomedical, electrical & computer, and mechanical) agreed to allow students to earn up to 3 technical elective credits from participating in the VIP program, while civil engineering did not, to avoid curricular changes at this point.

Student Journal Quality

As part of the VIP coursework, we integrated reflective journal assignments to encourage students to reflect on their experience (behavioral and affective responses) throughout the semester [11]. These assignments were also to be part of the qualitative data to research and evaluate the VIP program. To protect the confidentiality of students' responses and encourage them to write openly and honestly, the VIP team leaders did not have access to these journals until after the end of the semester (and after they had been anonymized). These efforts to protect student confidentiality may have led to students not seeing the purpose or benefit of the reflective writing assignment, resulting in brief, not very reflective journals.

For the spring semester, we implemented some changes to help make the purpose of the journaling assignments more apparent and potentially resulting in richer student journals (early spring journals show deeper, more reflective writing than in the fall). First, we added additional scaffolding to the assignment, with more direction for students and a more detailed evaluation rubric, so students receive quicker feedback on their journals (from the GTA). The VIP team leaders also now receive the anonymized student journals each week, so they can incorporate what they learn from these journals into the design and delivery of the VIP program on an ongoing basis.

Conclusion

As would be expected, there were some challenges associated with launching a new VIP program, but the lessons we have learned from this process may be useful to others seeking to implement VIP programs on their campuses.

First, better understanding student motivations for joining the VIP program may have helped retain more students into the second semester. We underestimated the extent to which some students were only participating to fulfill an honors seminar requirement, which meant they were no longer interested in continuing once that requirement had been fulfilled. Fully integrating the VIP program into students' degree planning is key.

Second, clearer communication regarding how course activities scaffolded and supported the research project might have resulted in more positive experiences for students who did not see the purpose of course assignments or who were disappointed in how much time was spent directly on research. Likewise, ensuring that student journals were integral to the course, to help students reflect on their experiential learning, would have enhanced the course's quality and research data.

Finally, while challenges were encountered, the overall impact of the program for the students was positive in terms of building community with their peers and developing deeper understanding in the technical focus area for their team. The unexpectedly positive response from the graduate students was an important result, as it indicates the role of VIP in developing leadership and mentoring skills in graduate students. These skillsets are often overlooked in

training and professional development of graduate students and are very important for preparing them for future careers in academia or industry.

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