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Vertically Integrated Projects (VIP) Programs at International Institutions: Multidisciplinary Projects with Homes in Any Discipline

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Vertically Integrated Projects (VIP) Programs at International Institutions: Multidisciplinary Projects with Homes in Any Discipline[1]

Abstract

A survey of papers in the ASEE Multidisciplinary Engineering Division for the last three years shows three main areas of emphasis: individual courses; profiles of specific projects; and capstone design courses. However, multidisciplinary education across all disciplines requires a larger-scale model that can be incorporated into any discipline, a model that is both cost effective and scalable, and one that fully engages and benefits faculty. A consortium of 19 US and 5 international institutions has come together around such a model, the Vertically Integrated Projects (VIP) Program. VIP unites undergraduate education and faculty research in a team-based context, with students earning academic credits toward their degrees, and faculty and graduate students benefitting from the design/discovery efforts of their multidisciplinary teams. VIP is novel because it unites rich student learning experiences with faculty research, transforming both the context of undergraduate education and the concept of faculty research as a separate endeavor. It provides a cost-effective, scalable, and sustainable model for multidisciplinary project-based learning: students earn academic credit instead of stipends; typical teams consist of fifteen or more students from different disciplines; students participate multiple years as they progress through their curriculum; and faculty benefit from the research and design efforts of their teams, with teams becoming integral parts of their research. While VIP programs share key elements, approaches and implementations vary by institution. This paper presents: an overview of the VIP Consortium; the multidisciplinary nature of the program within and across institutions; and profiles of 4 international institutions and their implementations of the model. The profiled institutions are based in Colombia, Korea, Latvia, and Scotland.

Introduction

The fragmented nature of higher education impedes many efforts to increase the number, quality, and diversity of STEM graduates. Universities' missions are subdivided into research, education, service, and economic development. Student learning is fractured into years, semesters, and class periods. Scholarship and research are subdivided into budgetary and disciplinary silos. This fragmentation prevents the type of long-term, in-depth, with-breadth learning that can keep students engaged and improve their learning and career preparation. The Vertically Integrated Projects (VIP) Program was created to overcome this fragmented environment.

Undergraduates who join VIP teams earn academic credit for their participation in discovery, design and other creative efforts that assist faculty with their research. Each team is: *large* – 10 to 20 undergraduates each semester; *vertically integrated* – including sophomores through PhD students each semester; *long-term* – each undergraduate may participate for three years, with

[1] This paper has a companion paper at the ASEE Annual Conference that discusses the characteristics of the set of US VIP sites. The overview of the fundamentals of VIP at the beginning of both papers is very similar, but the curricular organization and operation of the different VIP sites often vary substantially. Together, these papers show that VIP works in a wide variety of environments.

new students replacing those who graduate; and *multidisciplinary* – drawing students from *all* disciplines, especially STEM disciplines. The continuity, technical depth, and disciplinary breadth of these teams enable the completion of projects of significant benefit to faculty research. The result is the creation of a deeper, broader university community via collaborations that benefit everyone on campus.

With grants from the NSF and The Helmsley Charitable Trust, the **VIP Consortium** was established to further develop VIP and test its adoption at other universities. There are now 5 international institutions and 19 U.S. institutions in the VIP Consortium. This has shown that VIP works at many types of universities: large, small, public, private, Historically Black Colleges and Universities, Hispanic Serving Institutions, undergraduate-only, R1/2/3, and AAU institutions. This initial growth has provided the Consortium with insight into common elements of successful VIP sites: projects are started at the *request* of faculty members and other researchers; the program scales affordably when faculty are responsible for supporting the expenses of their teams; and shared infrastructure, including a server cloud that hosts grading, peer evaluation, and program management tools, helps VIP teams run efficiently and enables VIP Sites to scale well and quickly.

In this this paper, we present a detailed overview of the VIP model, an overview of the VIP Consortium, and profiles of four international institutions and their implementations of the model. The profiled institutions represent new and long-established VIP programs in four different countries, illustrating the adaptability of the model in different academic settings. Of particular note in all of these profiles is the way that VIP typically starts in one discipline but can then spread around the entire campus. This process is driven entirely driven by faculty and students. Faculty in any discipline quickly see how a VIP team can be a valuable partner in their research efforts and students browsing the list of VIP Projects can find a project that they are passionate about contributing to.

The VIP Model

The VIP Model involves **seven key elements** relating to the focus and scope of projects (2 elements), curricular structure (3 elements), and logistical considerations (2 elements).

Focus and Scope of Projects

Central to the VIP model is the **homing of VIP projects in faculty mentors' research**. The VIP program grew out of the Engineering Projects in Community Service (EPICS) Program [1-6], established at Purdue University in 1995. EPICS pioneered vertically integrated, large-scale, long-term undergraduate design teams. It was shown to meet nearly all of the ABET 2000 criteria [2,8], and it provided the *time* and *context* required for teams to solve the technology-based problems confronting local non-profit organizations [5,6]. EPICS received the Gordon Prize from the NAE in 2005 [6], and it is still operating at Purdue and many other universities [5,7].

A limiting factor in EPICS scalability was the disconnect between faculty reward structures and the community focus of the projects they were advising. Unless these projects are recognized within institutional rewards structures, instructor interest may wane over time. This waning

interest can be overcome with financial incentives, but this expense limits scalability. VIP kept the vertically integrated, large-scale, long-term structure of the student teams in EPICS, but shifted the focus of projects from community service to faculty research [9-14]. Homing VIP projects in faculty research enabled VIP teams to make meaningful contributions to their instructors' research, thus becoming integral parts of their instructors' funded research activities. The activities and support of the team could then be included as the education, broader outreach, and workforce development elements in proposals and sponsored projects. Together, these benefits establish deep, long-term faculty engagement with their teams.

Also key to the VIP model is the **long-term, large-scale nature of VIP projects**. Education is typically limited by course durations, with learning confined to narrowly defined semesters and academic years. VIP moves beyond the semester/academic-year model. While students join and leave the team at semester marks, projects last many years, even decades. Projects are also large-scale, with ten to twenty students per VIP team. This ensures that enough students will return each semester to maintain the continuity of the project. Beyond being functionally important in team management, large team sizes create student-to-faculty ratios that make the VIP model scalable in terms of students-served. This also enables faculty to take on projects not otherwise possible, thus expanding their research capacity and further contributing to deep faculty engagement.

Curricular Structure

Supporting the long-term and large-scale nature of VIP projects, VIP teams include a mix of **lower and upper level students** (even for the first semester of operation), and **each student can participate for at least two years, preferably three**. With this model for team composition, experienced students help on-board new students through student-developed tutorials, modules and peer mentoring. This lessens the burden on faculty and graduate students 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 lower and upper level students is important in this cycle, so lower level students can take the place of upper level students as they graduate.

Although VIP projects are not limited by semesters, **the VIP program is curricular, with all students participating for a letter grade**. The status of VIP as a curricular program differentiates it from clubs and extracurricular activities. Participation in VIP earns students 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. In support of the grading and evaluation, VIP programs require students to maintain rigorous documentation of their efforts, typically in the form of VIP notebooks or institution-approved electronic portfolios. VIP programs also involve peer evaluations, reflecting the team-based nature of the course. Georgia Tech has developed a web-based peer evaluation tailored to VIP, which will soon be piloted with a handful of consortium members.

As it was key to the VIP program from the beginning, the 2014 Consortium Planning Meeting participants articulated a key element for **learning outcomes that focus on the development of both disciplinary and professional skills**. In VIP teams, students apply skills from their

respective disciplines to advance their projects, and at the same time, 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 will be on-boarded by peers, but will also take responsibility for their own learning as they get up to speed. They will 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. They will also learn and apply professional communication skills, communicating problems to the appropriate individuals and navigating conflict. These skills are addressed in peer evaluations, with instructors providing feedback midway through and at the end of each term. This twice-a-semester feedback loop allows students to address areas in need of improvement prior to the end of the semester and prior to the beginning of their next semester on the team.

Logistical Considerations

Because VIP teams function more like research groups than courses, VIP teams need **dedicated, scheduled meeting spaces.** Team meetings for teams of 15 or more students, or subteams of 5 to 8 students, 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 of subteam meetings, outside of regularly scheduled full-team meetings, gives teams a home-base from which to work. Alternatively, some VIP teams meet in their faculty mentor's labs or departmental conference rooms.

The last key element defined by the consortium is 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 discipline/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 technical. It is after seeing how well-functioning VIP teams benefit their faculty and their students that departments typically adopt credit-use policies that allow a significant number of 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 only a few 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 already become multidisciplinary, attracting both students and instructors from other departments.

One significant advantage of the VIP Consortium, which is the topic of the next section, is that there are now examples of VIP teams homed in almost every discipline on campus, including all STEM disciplines. Furthermore, many of the institutions and disciplines that are home to these teams have created meaningful ways for VIP credits to count within their disciplines. These

precedents make it much easier for new VIP sites to get started and for credit policies to be implemented very quickly.

Cost effective, scalable

The unique strength of the VIP model is its ability to combine cost-effectiveness and scalability. These stem from four main traits:

- Long-term faculty engagement is achieved *without* recurring financial incentives.
- No stipends, salaries, etc. are required for participating students; they earn academic credits that count toward their degrees.
- High student to faculty ratios. The average number of students per VIP team at Georgia Tech, including new teams that intentionally start with fewer students, is 16 students.
- VIP works in any discipline. Thus, it is possible to assemble uniquely capable teams for a faculty member's project, regardless of what field is being considered. For example, *every* team at Georgia Tech is multidisciplinary and each student chooses to join a team whose area is of compelling interest to the student.

First and foremost 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 that are now required in many research 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. The exceptions to this policy implemented at some institutions include: (1) Release from one course for the ***first*** year that a team is in operation because that is when the burden of educating the team falls entirely on the faculty mentor. After year one, returning students take over the task of bringing new students up to speed. (2) In departments where VIP can be used to satisfy senior design requirements, a VIP adviser receives the same fractional-course teaching credit as regular senior design faculty for each senior design project homed within the team.

We have found that VIP works well in every discipline as a mechanism to enhance faculty research efforts. When this is combined with the ease of creating multidisciplinary VIP teams, faculty quickly discover that VIP teams offer them a unique new resource for their research. With an average team size of 16, it thus appears possible for ***every*** student on a campus to be involved in a VIP team. 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 possible already makes the VIP Program unique in terms of its potential for systemic reform.

VIP Consortium

The VIP Consortium [14,16] was established in 2015. Its goals are to expand VIP to all STEM fields and to a wide variety of institutions, to further evaluate its impact on students and faculty, and to organize an annual meeting for the Directors of all VIP sites. The Consortium initially included one international institution which had an existing VIP programs. The consortium now includes 5 international institutions, all in different countries. In the following sections, 4 of these international VIP sites provide overviews of their VIP Programs, illustrating unique aspects of VIP Programs at each institution.

VIP Program Profiles

Inha University VIP Program
Location: Incheon, South Korea
Initiating Department: Department of Information & Communication Engineering

About the Institution: It has been over 60 years since Inha University was established upon the ideals of leadership, expertise, and service to the country. A mainstay in the port city of Incheon, Inha has long produced talented professionals for the science and technology sectors, who have exceeded the expectations of the nation and its people. The first classes were held on March, 1954, with six majors. Now, Inha has 56 departments and 17,477 students enrolled in Spring, 2016. In particular, Inha has become one of the strongest engineering-oriented universities in Korea, with almost 8,000 undergraduate and graduate students in 21 engineering departments.

Background & Implementation: In order to contribute to the development of new industries by cultivating talent equipped with integrative capability suitable for quickly changing societal trends, Inha established the VIP program. The VIP program can be considered a capstone design course having the features of 1) project-based learning, 2) team-based learning, 3) multi-disciplinary learning, and 4) multi-semester learning. In each VIP project, students make teams consisting of multi-disciplinary and multi-year students, and carry out a specific research project guided by a professor. During the class, the professor's lectures are minimized; instead, the interactions of students with the professor, graduate mentors, and industrial experts are largely required. The VIP program is designed so that the students can gain: 1) both basic and applied knowledge related to the project, 2) problem-solving skills, 3) fellowship and leadership in teamwork, and 4) communication skills. In the 2016 school year, ten VIP projects were under way, involving 189 students from 22 departments from 3 colleges of Inha's 15 colleges.

Ten VIP projects were in operation in Fall semester of 2016:

- Intelligent automobile technology
- Reconfigurable Share-Use Mobility System (PACE Project)
- Chemical sensitive sensor development
- 3D measurement technology
- Smart Monitoring
- Smart Sensing
- Planning and designing creative products using MCU (Micro Controller Unit)
- Study on the convergence between ceramic product and 3D printing technology
- Development of Minimum Viable Product (MVP) using Lean Startup

Students participating in the VIP program can earn a maximum of 3 credits of in-major electives and another 3 credits of free electives throughout 6 semesters (Table In-1). Thus the program is approved as a general design course in engineering departments. In regard to student evaluation, the final grade is determined based on oral presentations, a research diary, peer evaluations by the team, and a final demonstration. Since 2015, industrial enterprises related to each research subject have participated in the VIP program through mentoring support and student/project

evaluation. In Spring, 2017, two research subjects regarding Deep learning and Big-data analysis will join Inha's VIP program, and more students are expected to enroll.

Program Composition: Inha University initiated the VIP Program in Spring, 2014, with 46 students enrolled in 3 research subjects. With the purpose of improving undergraduates' integrated research ability in diverse engineering disciplines, the VIP program has become a unique course where students of all years (from freshmen to seniors) and from many majors (engineering plus the arts and social studies) perform certain projects lasting for several semesters. In Fall, 2016, VIP had grown to 106 students in 10 research projects (Figures 1 and 2).

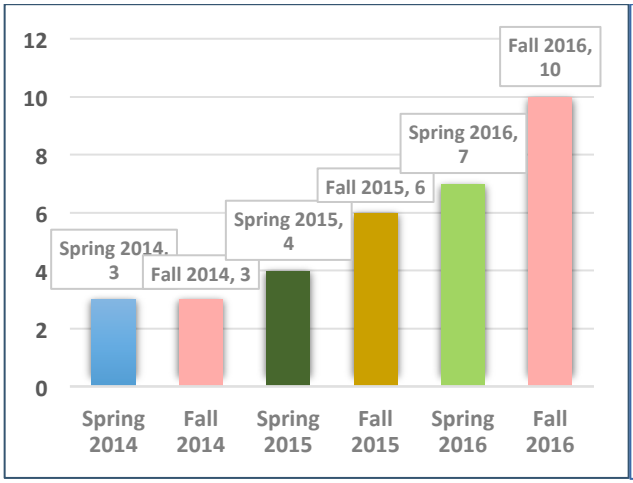

Figure 1: Growth in participating professors

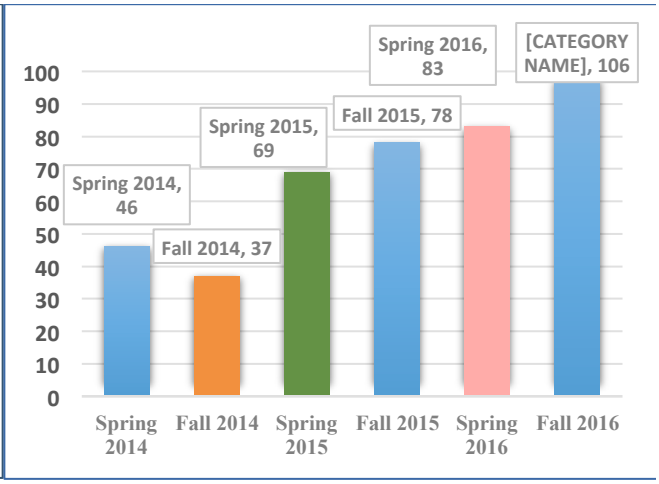

Figure 2: Growth in participating students

Table 1. Course credits and Participating departments

Course name (Course ID)	Credit	Departments
VIP 1 (ACE9501)	In-major elective	Mechanical Engineering Naval architecture & Ocean Engineering Chemical Engineering Polymer Science and Engineering Applied Organic Materials Engineering Civil Engineering Geoinformatic Engineering Architectural Engineering Information and Communication Engineering Visual Communication Design
VIP 2 (ACE9502)	In-major elective	
VIP 3 (ACE9503)	In-major elective	
VIP 4 (ACE9504)	Free elective	
VIP 5 (ACE9505)	Free elective	
VIP 6 (ACE9506)	Free elective	
Total	6 credits	

Unique to this Program: The Inha VIP program is the only credited course nation-widely in Korea from the following aspects: i) learning by performing research projects guided by professors, ii) team-based learning with the members in diverse years from cross disciplines, and iii) receiving financial support ($9,000 annually) for equipment and material from a government funding project of Engineering Education Innovation since 2014.

University of Strathclyde VIP Program
Location: Glasgow, United Kingdom
Initiating Department: Launched Institute Wide

About the Institution: The University of Strathclyde is a large public institution with over 21,000 students (14,500 Undergraduate and 5.500 postgraduate) studying across four schools, Engineering, Science, Business, and Humanities, Arts and Social Science. There is a strong technological theme with a high level of industrial engagement. It began its VIP program in 2012 and now has over *230 students* on *8 projects* spanning all four schools.

Background & Implementation: The seeds of VIP were sown at the University of Strathclyde in August 2010 when a visit was made by Ed Coyle, who happened to be at a conference nearby. Ed has known the Academic Lead of VIP, Steve Marshall for many years through their common research interests. Ed delivered a talk about VIP which was well received by Teaching and Learning staff. At a Strategic Meeting of Senate some months later, the University Leadership had set the task of identifying news ideas for *Innovation in Teaching* and VIP was selected as the most exciting and innovative. Having decided to establish a VIP Program, we invited Ed to visit for an extended period and identified a series of academic staff that we felt were good candidates for leading VIP projects. We brought them up to speed and asked them to identify slots in their curriculum where VIP could be accommodated. In 2012 we launched with 4 VIPs and have since doubled this.

Faculty/ Department Motivations: There are many reasons for faculty to participate in VIP. In some cases, this can be enlightened self-interest by the Faculty. For example, it is now important that Life Science students gain experience with computer-based tools, which can be achieved through VIP. One project – a Performance and Drama VIP – can be used to generate interest in *STEM* subjects via the support of Science staff and students. In another VIP project, school children were encouraged to come to the university to build remote vehicles. This project was specially designed to get more girls, especially from ethnic backgrounds, to become engaged in Engineering to address our targets on *Gender equality* and *Widening access*. In the case of our students, many see VIP as increasing their employability by giving them a broad set of skills from computing to project management. This is even more important in majors that are not directly vocational.

VIP Program Composition: The VIP program has students from 22 Departments covering more than 35 Majors from across the University. As described above these projects are very diverse.

Unique to This Program: The Strathclyde VIP program is very diverse, including the first ever projects in Humanities, Entrepreneurship, and Life sciences. All projects are multidisciplinary

and some are highly cross disciplinary combining, for example, English Literature with Computer Science, Biology with Maths, and Engineering with Business.

Most of the projects have an outreach aspect engaging with local Businesses, High Schools, and the field of International Development. As well as having a number of VIPs in Entrepreneurship, there are also Business students allocated to other VIPs to identify value and explore fundraising, licensing and marketing. In other VIPs, Business students have worked with leading research groups to identify market opportunities for emerging technologies.

With the recent increase in emphasis on Global Challenges (United Nations' Sustainable Development Goals), the VIP program is seen as an ideal vehicle to address these challenges and to bring together both the Faculty and students to learn to work together in a cross disciplinary way. As such, VIP projects are now asked to align with one or more of the seventeen Sustainable Development Goals that were launched in 2016 by the United Nations. Through VIP, Strathclyde intends to inspire our undergraduate students to make their own contribution to the overall aims of sustainable global development. The experience of co-mentoring a cross-disciplinary Vertically Integrated Project can bring Faculty together and lay the foundations of joint research proposals.

In 2016 a VIP Conference was held at Strathclyde, inviting all Strathclyde VIP projects to submit a short abstract describing their research and all VIP teams were invited to deliver poster presentations at the event. A shortlist was also selected to give an oral presentation to an audience of fellow VIP students and University research staff and students (approx. 100 attended). The students' presentations and posters were judged by representatives from industry and modest prizes were awarded. It is also worth noting that – in the true spirit of VIP involving students in 'real-world', for-credit experiences – the VIP conference was organized by a team of students from a Hospitality Management course within the Strathclyde Business School. In 2017, an additional event modeled after Dragon's Den was introduced at the second Strathclyde VIP conference. Six VIP teams applied to participate and four successful VIP project teams delivered a pitch at the conference for investment of up to £3000 in their VIP research. The pitches were made to a panel comprised of high-profile individuals from industry and government funding bodies. The winning team was awarded £2500 to support their research in using image processing to create new tools for drug discovery. Two other teams won £1500 each, which will support one team with their research in sustainable energy for 3rd world countries and another with their engagement with local schools. Funding for this activity was obtained via a successful application made to Strathclyde's Alumni and Development fund and was topped up by a philanthropic £500 cash contribution from a member of the judging panel.

Riga Technical University (RTU) VIP Program
Location: Riga, Latvia
Initiating Department: Office of Vice-Rector for Research, RTU Design Factory

About the Institution: RTU is the largest university in Latvia, enrolling approximately 15,000 bachelors, masters and doctoral students.

Implementation Background and Plans: The idea of introducing the VIP Program in Latvia originated during the visit of RTU vice-rector of research to Georgia Tech in 2014, which was organized jointly with Latvian Ministry of Education and Science. It was followed by a return visit of VIP representative Ed Coyle to Riga with a lecture about the VIP program. After that, a working group consisting of professors, administrators and the coordinator of RTU Design Factory (http://rtudf.rtu.lv) was set up. This group decided to start a pilot with 4 VIP teams in the Spring semester of 2017. The course was advertised on the local website: https://www.rtu.lv/lv/universitate/masu-medijiem/zinas/atvert/rtu-studentiem-iespeja-pieteikties-jaunam-studiju-kursam-dizaina-fabrika More than 70 students applied for the course, from which 25 were selected by professors.

VIP Program Composition: It was decided that each of the VIP project teams will include undergraduate, doctoral students and students from the RTU Engineering High School (http://www.izv.lv/?lang=en). Four teams were selected by professors from different faculties (schools):

- Sensor networks for smart cities
- Large-scale synthesis of nanomaterials
- Smart textiles for future applications
- Multiple robot applications in agriculture

The course supporting the VIP Program is an elective with 2 credit points (80 hours). The lectures and instructions, as well as prototyping, are organized within the premises of the RTU Design Factory. Experiments and fieldwork are conducted at the laboratories associated with the advisors of each project team.

Unique to this Program: The program in Riga is organized with the support of RTU Design Factory, which provides knowledge in engineering design, skills in technology prototyping, and availability of equipment. The mentorship support is also provided to the professors to guide (when needed) students' work.

As the program has just started there are only a few general observations we can make so far:

- In the early phase of ideation, there is a need to find a balance between the openness to ideas and providing concrete instructions by professors; if not students, might lose the track and interest;
- Each student needs to have or be given a task after every meeting;

VIP Program: Universidad del Norte
Location: Barranquilla, Colombia
Initiating Department: Department of Electrical and Electronics Engineering, College of Engineering

About the Institution: Located in the coastal city of Barranquilla, Universidad del Norte is the main academic center for higher education in northern Colombia. It is a private institution which started academic operation on July 11, 1966. Today, Universidad del Norte serves over 12,000 undergraduate students and about 3,300 postgraduate students, and is listed among the five best universities in Colombia. The institution is organized around ten academic divisions, including: Engineering, Administrative Sciences, Humanities and Social Sciences, Health Sciences, Legal

Sciences and Basic Sciences. Overall, Universidad del Norte offers 28 undergraduate programs, 90 professional specialization programs, 52 masters programs, and 15 doctoral programs. In particular, the college of Engineering offers degrees in industrial, mechanical, systems, civil, electrical and electronics engineering. All undergraduate engineering programs are ABET-accredited.

Background and Implementation Plans: Interest about setting up a VIP program at Universidad del Norte arose during Spring 2016, from communications between one of our faculty at the Department of Electrical and Electronics Engineering (DEEE) and his former PhD adviser at Georgia Tech, who runs one of the VIP teams there. Dr. Edward Coyle, VIP director at GeorgiaTech, was invited to our campus during Summer 2016 to present the program to different academic and administrative authorities at the College of Engineering (CoE) and the university level. From those starting activities, the dean of the CoE approved support to run a local VIP program from the DEEE. Fall 2016 was used to plan and execute the initial stages of our VIP program particularly from the curricular, administrative and logistics points of view, as detailed below:

Curriculum: In general, our undergraduate programs are not very flexible in curricular content, so finding how to incorporate classes associated with a VIP program proved to be an initial challenge. With help from the Registrar's office, we were able to use existing but until now unused class codes assigned to 'Research Internships' to create classes associated to VIP. We offer three different levels of VIP classes, with 1, 2 and 3 academic credits each. Students in the DEEE can use those credits in three different ways: The first alternative is to use 3 VIP credits (earned in a single or multiple semesters) as a free elective in their course plan, up to a maximum of 9 VIP credits (which correspond to the 3 free electives currently included in the DEEE course plan); A second option is to use 3 VIP credits as one of the technical electives currently included in the DEEE course plan, in this case only one elective from the required three can be replaced by VIP credits; the last option is to use any number of VIP credits as extra credits, which do not count toward graduation requirements but are included in GPA computations. Currently the program is DEEE centric, although students from other departments can register for VIP classes, they can only use those credits as extra credits that do not count toward graduation requirements. We expect that as the VIP program grows other departments will adopt a policy with regard to VIP credits that is similar to the one currently used by the DEEE.

Administration: Our undergraduate programs are 5 years (10 semesters) long. Students from the 5^{th} to the 10^{th} semester (3^{rd} to 5^{th} year) can apply for a VIP team. Registration for VIP classes is by permit only, interested students must contact faculty in charge of the teams and then those professors send a list of approved students to the respective undergraduate program coordinator to register them. We have devised a general grading scheme heavily based on the one used by the VIP program at Georgia Tech, but adapted to our particular conditions and rules. VIP courses are graded on the regular school scale (from 1.0 to 5.0); however, our VIP grading scheme aims to give faculty more flexibility regarding how to assign final grades than for regular courses. Our VIP program director is responsible for verifying the correct application of grading and registration rules by all teams, and also acts in cooperation with undergraduate program coordinators to resolve any administrative issue that may arise. Since our program is still in an

early stage, we expect our current rules to be fluid and therefore refined according to feedback from all actors involved.

Logistics: The DEEE assigned a room in our laboratories as a VIP meeting room. Except for a few graduate level classes, this room is exclusively available for VIP work. It must be noted that this arrangement shows the interest of the DEEE for the success of the VIP program, given the current shortage of physical space in our laboratories. The room has multimedia equipment for presentations and video-conferences, it also has a few PCs set aside exclusively for VIP use. The default physical layout of the room (tables, chairs and some electrical outlets) is of a 'round table' style commonly used in professional meeting rooms; however, it can be easily rearranged for different configurations according to the needs of the teams, for example regular classroom configuration or independent tables for subgroup laboratory work. Teams have an official 2-hour weekly meeting at this room, but students are expected and encouraged to use the room's facilities at other times to work on their VIP project duties. The equipment and accommodations of the VIP room have been provided by the DEEE. To work on the actual projects, VIP teams are using a combination of existing resources of the DEEE laboratories/research groups, funding from professors projects, and self-funding by team members. Our plan is to use preliminary results from VIP work to apply for sponsorship from grants and/or industry. Additionally, we believe that this area of funding is one of the key opportunities to develop as part of an international VIP consortium. From our point of view, developing collaboration with VIP teams at other institutions should help to not only to widen the available pool of funding options, but also to increase the chances of successful applications, therefore benefiting all participating institutions.

VIP Director: Winston S. Percybrooks, PhD, faculty at the DEEE. In charge supervising the general operation of the program as well as its future development, his duties so far include: setting up the program, monitor student enrollment, program promotion, propose changes to the DEEE head and CoE dean regarding the program, as well as participating in activities organized by the VIP consortium.

VIP Program Composition: Our VIP program is now (Spring 2017) on its first semester of classes. We have two teams, led by two professors from the DEEE, with 26 enrolled students. The program organization and teams are described below:

Team Energinators:

- This team works on topics related to the concept of node-sourcing, which aims to exploit alternative energy sources available in a particular operating environments to power electronic devices. The current team interests are: photo-voltaic cells, wind power generators, energy harvesters, power-independent telemetry systems, among others.
- Members:
  - Faculty lead: Mauricio Pardo, PhD, faculty and head of the DEEE.
  - Graduate lead: José Manjarrés, PhD student at the DEEE.
  - Undergraduates: 16 students from the DEEE, ranging from 6^{th} to 10^{th} semester.

Team DSPlorers:

- This team works on topics related to applications of digital signal processing and machine learning to solve real life problems. Currently the team is working in two main areas: the acquisition, processing and understanding of biological signals in health and entertainment applications; the use of robotics, DSP and machine learning to construct autonomous land and water vehicles for specific applications.
- Members:
  - Faculty lead: Winston S. Percybrooks, PhD, faculty at the DEEE
  - Graduate lead: Pedro Narváez, PhD student at the DEEE.
  - Undergraduates: 10 students from the DEEE, ranging from 6^{th} to 9^{th} semester.

Program goals: In Colombia, graduate level education and research, especially in STEM fields, is still in a maturing stage, so a lot of work still relies on undergraduate students. However, recent curricular changes to align our undergraduate program with the U.S. and European models have moved the undergraduate research activities out of the curriculum. As a result, undergraduate students with research and development interests have been forced to find professors, who are struggling to advance research programs with a only few graduate students, to collaborate in research activities in a mostly extracurricular and informal environment. Therefore, one of the main motivations for starting a VIP program in our school was to better articulate the extra curricular research work that some faculty were already undertaking with undergraduate students. This allows students, on one side, to be in contact with research activities in more formal and possibly more rewarding conditions. Faculty, on the other side, can get critical junior members for their groups to help advance their research agendas. Our immediate goals regarding our VIP program are:

- Begin achieving technical results, in the form of prototypes, software and possibly publications, with two objectives: first, to be able to prepare stronger proposals for funding/sponsorship; second, to use those results to help promote the program among faculty and students.
- Generate interest in other departments to formalize VIP credits in their curriculum, therefore broadening the institutionalization of the program and facilitating the participation of students from diverse programs/schools, creating multi-disciplinary teams.

Longer term goals for our program are:

- Serve as a recruiting tool for our graduate programs, helping us to identify undergraduate students with the skills and interest for graduate work.
- Create collaboration with VIP teams in other institutions, to pool technical knowledge and skills as well as funding opportunities.
- Our school has a growing number of low-income students, mainly in STEM fields, thanks to a recent national government program that offers an important number of scholarships for high-performing but low income graduating high schoolers. Until recently, those students would not have the opportunity to attend college. With the VIP program we want to expose them to STEM research so they can consider alternatives for continuing their education at the graduate level, hopefully helping consolidate our still maturing research and development system.

- Spread the VIP model to other institutions in the country/region.

Conclusions

This paper and a companion paper on the implementation of VIP Programs by US institutions illustrate the ways in which the VIP model can adapt to and work well in wide variety of institutions. The primary differences we have noticed across *all* VIP sites are in: the curricular structure into which VIP must be merged; the ways that VIP credits count toward students' degrees in these curricula; and the level – department, college, or university – at which the program is initiated. Given those differences, we have found that VIP Programs that follow the seven key elements described in the VIP Model Section have been launched successfully and have shown the ability to scale-up and be very visible within their university.

Perhaps the most notable aspect of the VIP Program, which is clearly visible in the description of the four programs in this paper, is the wide variety of disciplines in which successful VIP teams can be found. They include virtually every engineering discipline, the sciences, computing, liberal arts, social sciences, and business. In many cases, these VIP teams are themselves multidisciplinary, even if they were launched initially within one discipline. The VIP Program is thus unique in its ability to offer compelling multidisciplinary projects that are both sustainable and scalable. The reason for this success is that VIP provides a framework in which professors can create and students can find, join and contribute to projects about which they are all passionate.

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