The Vertically Integrated Projects (VIP) Program and Consortium: Enabling Everyone to Work Together

Director: Ed Coyle
Co-Director: Randy Abler
Assoc. Director VIP Consortium: Kitty Vogt
Asst. Director: Julie Sonnenberg-Klein
Program Manager: Chris Malbrue
Goal: Involve *Everyone* in Scholarship and Exploration

Scholarship and Exploration

• **Scholarship**: Development of Deep Knowledge and Expertise in One or More Fields

• **Exploration**: Acts of Discovery, Design, Creativity, Innovation, Research in One or More Fields

• Present in all Academic Disciplines!
Barriers: The 3 Forms of Fragmentation

Fragmentation By Time
 Primarily affects Undergraduates
 Semesters; Academic Years

Fragmentation By Mission
 Primarily affects Faculty and Staff
 Exploration / Scholarship / Outreach

Fragmentation By Discipline
 Affects Everyone
 The “Thinkings,” Budget Lines, Culture
Barriers: The 3 Forms of Fragmentation

**Fragmentation By Time** 1995

VIP 1.0: Engineering Projects in Community Service (EPICS)
First Vertically Integrated Project (VIP) Teams: Focused on the Community

**Fragmentation By Mission**

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First Vertically Integrated Project (VIP) Teams: Design for the Community

Fragmentation By Mission 2001
VIP 2.0: Vertically Integrated Projects (VIP) in ECE
VIP Teams embedded in Faculty Scholarship and Exploration in ECE

Fragmentation By Discipline
Affects Everyone
The “Thinkings,” Budget Lines, Culture
Barriers: The 3 Forms of Fragmentation

**Fragmentation By Time** 1995
- VIP 1.0: Engineering Projects in Community Service (EPICS)
  - First Vertically Integrated Project (VIP) Teams: Design for the Community

**Fragmentation By Mission** 2001
- VIP 2.0: Vertically Integrated Projects (VIP) in ECE
  - VIP Teams Embedded in Faculty Scholarship & Exploration in ECE

**Fragmentation By Discipline** 2009
- VIP 3.0: Vertically Integrated Projects Program and Consortium
  - Multidisciplinary VIP Teams embedded in Faculty Scholarship & Exploration
The VIP Approach: Integrate Scholarship & Exploration

Foster Scholarship & Exploration by Involving Students in Challenging Projects Led by Academic Staff

Ensure Success by Providing:

- Time
- Context
- Mentoring
VIP: Bringing People Together

Students need Real Projects in which they Participate in Scholarship and Exploration.

Faculty can Benefit from Help in all Aspects of Scholarship and Exploration.
VIP Program Architecture: The Basics

Enable Long-Term, Large-Scale, Multidisciplinary Teams

• Project teams led by faculty; embedded in their S&E activities
• Large teams: 10-20+ undergraduates; 1-4 grad students
• 2nd through final year undergraduates students on every team
• Long-term participation – up to 3 years per student
• New students replace those who graduate
• Students drawn from all disciplines needed by the project
• Teams continue for many years
• Academic credit and grades each semester
Example: The 18 year old Stadium-IoPT Team
The Stadium-IoPT Team’s Testbed: Bobby Dodd Stadium
People and Information: In-Stadium Web Apps in 2001

Video clips, stats, tracker on your phone during a game:
http://estadium.gatech.edu
Stadium IoPT Wireless: Baseball Stadium

• WiFi–Mesh for easy installation in old stadiums
• 802.11a Backbone; b,g,n for Fan Access
Stadium-IoPT Wireless: The Gateway

A WiFi Mesh Node: 3 APs per node
One 802.11a Backhaul; Two 802.11b,g,n for Fans
Stadium-IoPT: Sensor Net Subproject

Sensing Tasks:
- Vibration, Audio, Spectrum
- Sensors vary node-to-node
- Processing tasks differ
- Energy varies node-to-node

Sensor Net Sub-Project:
- Many sensor motes
- 6-month football season
- Supports many applications
Stadium-IoPT: Sensor Net Subproject
Stadium-IoPT: Sensor Net Subproject
Stadium-IoPT: Sensor Net Subproject
Stadium-IoPT: Sensor Net Subproject

• 40~50 Sensor Motes
• 10~12 ClusterHeads
• Cognitive Radio Backhaul
• <125μsec Synchronization
Stadium-IoPT: Sensor Net Subproject

Sensing Vibrations
Stadium-IoPT: Game Vibrations

- Touchdown by Miami
- Advertisement on the big screen
- Half-time break
- "Make some Noise"
- Introducing 1990 national champion team + half time show
- Touchdown by GT
- Touchdown by Miami

Acceleration in g vs Time in seconds
Georgia Tech VIP Teams: Spring 2019

• 70 Teams; 1103 Undergraduates Enrolled

• Students and Faculty from: Business, Computing, Design, Engineering, Liberal Arts, and Science

• List of GT VIP teams. Click on any team’s icon to see a one-page description of that team and the list disciplines from which that team is seeking students:

http://www.vip.gatech.edu/teams
VIP Enrollment Spr ‘19: Team Size + Majors

Major Distribution by Team Spring 2019
VIP Classes

Count of Number of Records
VIP Enrollment Spr ’19: Majors ->

Major Distribution by Team Spring 2019

VIP Classes

Count of Number of Records

Aerospace Eng
Applied Physics
Applied Physiology
Architectural Technology
Architecture
Bio Eng
Biochemistry
Biology
Biomedical Eng
Business Admin
Chemical and Biomolecular Eng
Chemical Eng
Civil Eng
Computational Media
Computational Science Eng
Computer Eng
Computer Science
Electrical and Computer Eng
Electrical Eng
Environmental Eng
History and Sociology
Human-Computer Interaction
Industrial Design
Industrial Eng
International Affairs and Modern Language
Machine Learning
Materials Science and Eng
Mathematics
Mechanical Eng
Music Technology
Neuroscience
Physics
Psychology
Robotics
Special Non-Degree
Undeclared College of Engineering
VIP Team Creation and Persistence
Cross-Campus Collaboration, GT

1/3 of VIP teams draw instructors from more than one GT Unit.

VIP Team
- Academic Resilience
- Agile Communication Architectures
- AquaBots
- Augmented Reality Experiences
- Bee-Snap
- ChemFlow
- Chip Scale Power & Energy
- Civic Data and Design
- Data-Driven Education
- EcoCAR
- Engineering for Social Innovation
- Engineering Smart Cities
- Hands-on Learning
- Humor Genome
- Intelligent Transportation Systems
- IP Crowd
- Smart City Infrastructure
- STEMcomm

GA Tech Schools & Units
- Computational Science & Engineering
- Computer Science
- Interactive Computing
- Interactive Media Technology Center
- Center for GIS
- Biomedical Engineering
- Chemical and Biomolecular Engineering
- Civil & Environmental Engineering
- Electrical and Computer Engineering
- Industrial & Systems Engineering
- K12/Diversity
- Material Sciences
- Mechanical Engineering
- Literature, Media & Communication
- Biology
- Chemistry
- Earth and Atmospheric Science
- Mathematics
- Physics
- Psychology
- C21U
- Facilities
- GTRI
- Professional Education
VIP Team Composition: By Academic Rank, Spr 2018

UG Enrollment by Academic Rank, Spring 2018

- Seniors, 408 (45%)
- Juniors, 308 (34%)
- Sophomores, 175 (19%)
- Freshmen, 15 (2%)
- Special Undergraduate,...
VIP Teams: Disciplines of Advisers, Spr. 2019

<table>
<thead>
<tr>
<th>15 Electrical and Computer Engineering</th>
<th>7 Aerospace Engineering</th>
<th>7 Civil &amp; Environmental Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Mechanical Engineering</td>
<td>3 Chemical and Biomolecular</td>
<td>2 Industrial &amp; Systems</td>
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<tr>
<td></td>
<td>2 Biomedical</td>
<td>2 Industrial Systems and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Material Science</td>
</tr>
<tr>
<td>33 GTRI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- CSE
- CDC
- Mechanical Engineering
- Library
- Physics
- Biology
- Math
- Psych
- Literature, Media & Communication
- Modern Languages
- Pub Policy
- GIS
- Music Center
VIP@GT Course Structure: Campus-wide Courses

<table>
<thead>
<tr>
<th>Year</th>
<th>1 credit</th>
<th>2 credits</th>
<th>3 credits</th>
<th>For pay (0 credits)</th>
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<tbody>
<tr>
<td>2nd Year</td>
<td>VIP 2601</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3rd Year</td>
<td>VIP 3601</td>
<td>VIP 3602</td>
<td>VIP 3603 by dept. request</td>
<td>VIP 3600</td>
</tr>
<tr>
<td>4th+ Year</td>
<td>VIP 4601</td>
<td>VIP 4602</td>
<td>VIP 4603 by dept. request VIP 4813 capstone</td>
<td>VIP 4600</td>
</tr>
<tr>
<td>Graduate</td>
<td>VIP 6601</td>
<td>VIP 6602</td>
<td>VIP 6603</td>
<td>VIP 6600</td>
</tr>
</tbody>
</table>

- Each course can be taken multiple times
- Each team is one section of every course
- Available to all Disciplines
Evaluating the Performance of VIP Students

• Grading Process: Middle and End of Each Semester
  • Every Student Graded A, B, C, D, F / Other Scales Possible
  • No P/F, No Auditing, No Volunteers

• Peer Evaluations – Specific to VIP (CATME not a good fit)

• Three Components in Grading:
  • **Documentation**: Journals, Wiki, GitHub, Presentations, Reports, ...
  • **Individual Contributions**: Judged by Team Advisers
  • **Teamwork**: Observations plus Peer Evaluations
<table>
<thead>
<tr>
<th>Credits</th>
<th>Class</th>
<th>Major</th>
<th>Semesters</th>
<th>Email</th>
<th>Wiki</th>
<th>Peer Eval</th>
<th>Enter Grades</th>
<th>Release Student Grade</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>JR</td>
<td>CMPE</td>
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<td>Wiki of / by</td>
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<td>EE</td>
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<td>Wiki of / by</td>
<td>Edit / View</td>
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<td>CMPE</td>
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<td>Wiki of / by</td>
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<td></td>
<td>Wiki of / by</td>
<td>Edit / View</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Grading Form: Categories

Documentation
A- Notebook Maintenance
A- To Do Lists
A- Meeting Notes
A- Usability
A- Overall Design Notebook Evaluation
B- Wiki Content Quantity
A- Wiki Content Quality
  SVN code logged frequently
  Code Quality
A- Overall Documentation

Accomplishments and Effort
Tutorials and Learning Modules
Team and sub-team quizzes
Papers and Technical Articles
A- Pursues Independent Learning
A- Self Motivated
A- Independent Effort
B+ Quality of Effort (results)
A- Overall Effort

Teamwork and Interaction
Team meeting attendance
Team meeting participation
A- sub-team meeting attendance
A+ sub-team meeting involvement
A- Contributes useful ideas
A- Recognizes others ideas
B- Focuses effort on achieving goals
  Involves others in effort
A- Assists others with their efforts
  Manages time and tasks well
B- Leadership skills
  Final Presentation
  Peer Evaluations
A- Overall Teamwork Evaluation
Grading Form: Personalized Feedback

You are an experienced and valuable member of the [blank] subteam. You document things well, help new members start-up, are active in many ways, are knowledgeable, etc. Recently you have started taking a leadership role, which is MUCH appreciated because the team was really drifting -- in part because there was a vacuum after [blank] graduated. I like that you volunteered to meet with your team's customer, the [blank] team.

One area in which you need to improve is how you lead now that you have assumed a leadership role. You need to be more organized and to keep things focused. You have a tendency in discussion to get off track, sometimes never returning to what really needs to be done. To fix this, come into each meeting with a checklist of things that the team needs to focus on and work through it. If you feel you need any help with leadership at any point, ask Randy or me for advice.

Also, please don't make the same mistake that [blank] made, which was to not foster other leaders before leaving.

Overall, you are doing a very good job, so keep working on improving your performance and the team's performance.
Team Structure

- **Team Size**: Avg = 16, Largest = 50, Smallest = 8
- **Almost Every Team has Sub-teams**: Typically 4 to 8 Students
  - Experienced Students are Sub-Team Leads
  - Experienced Students + Advisers Coordinate across Sub-teams
  - Takes 2-3 Semesters for a Team to Build Experience/Structure
- **Need to Understand Team Members’ Interactions**
  - Peer Evaluations
  - Social Network Analysis
<table>
<thead>
<tr>
<th>Question</th>
<th>1/5</th>
<th>2/5</th>
<th>3/5</th>
<th>4/5</th>
<th>5/5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How often do you interact with each person below?</td>
<td>5/5</td>
<td>5/5</td>
<td>5/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. How often do you get suggestions/advice from each person below?</td>
<td>5/4.7</td>
<td>5/4.7</td>
<td>4/4.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. How often do you give suggestions/advice to each person?</td>
<td>5/3.7</td>
<td>5/3.7</td>
<td>5/3.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Participation in team meetings/class:</td>
<td>4/4</td>
<td>4/4</td>
<td>4/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Participation in subteam meetings or breakout discussions:</td>
<td>5/4</td>
<td>4/4</td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Quality of work:</td>
<td>4/4.7</td>
<td>5/4.7</td>
<td>5/4.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. When encountering obstacles, how does each person react?</td>
<td>5/5</td>
<td>5/5</td>
<td>5/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Independent Learning:</td>
<td>5/5</td>
<td>5/5</td>
<td>5/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Team management ability:</td>
<td>5/4</td>
<td>4/4</td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Imagine your team is a company and you are the manager. VIP, Inc. has asked you to divide $10,000 in bonus money among the members of your team. EXCLUDING yourself, decide how the bonus should be divided.</td>
<td>4000 / 3333.3</td>
<td>4000 / 3333.3</td>
<td>2000 / 3333.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Comments: Please leave comments on each person below for your instructor(s). Constructive criticism is especially helpful.</td>
<td>Very passionate about the team.</td>
<td>Very dedicated to learning what is needed for the team. Could participate in discussion more.</td>
<td>Very knowledgable on the material related to the team. Needs to be more committed.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Social Network Analysis

Arrows Show Direction of Advice/help

Weight of Arrows Shows Frequency of Advice

Size of Circles ~ Sum of Incoming Ratings
How VIP@GT Credits Count: ECE/BME Example

Provide Incentive to Participate Multiple Years

- Take 5 or fewer credits:
  - All are Approved-Elective (Free-Elective) Credits
- Take 6+ credits:
  - 3 or 6 of them Become Technical Elective Credits
  - Rest are Approved-Elective (Free-Elective) Credits
- VIP + VIP Senior Capstone: 8+ Credits
  - 3+ Credits as a Junior (VIP-3601/2 then VIP-3602)
  - 2 Credits (VIP-4602) 1st-Semester Senior Year
  - 3 Credits of VIP Senior Design (VIP-4813)
ABET + "Senior Design” + VIP

• ABET is NOT a Problem for VIP
  • Can have multiple ways in your department to provide design experience
  • Do not need to remove seniors from their VIP team!
  • VIP provides a realistic, multidisciplinary design experience that is very difficult to achieve in traditional senior design.

• VIP teams are large, vertically integrated, and long term, so the experience is much closer to what happens in industry.

• Ideal: Discipline-Centric Design early in curriculum, followed by or in parallel with a VIP experience.
  • Traditional “Senior Design” still available for those who do not do VIP
Faculty Credit Options (Current Curriculum):

No Course Release for Adviser(s)
- Works in Depts with Low Teaching “Loads”
- Faculty will do VIP because it helps their research

One Course/Year *every year* for Primary VIP Adviser
- ½ Course/Semester matches actual time commitment
- 24+ distinct students/year for each year team operates
- Works if VIP counts as dept elective(s)/capstone

One Course/Year for *first 2 Years* for Primary VIP Adviser
- Gives credit when educating team falls on adviser
- Team is providing research benefits by year 2
- Allows dept to launch a specified # of new teams each year
Access and Diversity for VIP@GT

● **Credit bearing + counts toward degrees:** Enables *all* students to participate

● **Joining teams:**
  No interviews, GPA requirements, or Prerequisites

● **Unique among High-Impact programs:**
  %URMs in VIP = % in overall student population.

● **High Participation amongst Transfer Students**
Assessment: Many Aspects

Ongoing Study of Learning Outcomes + Impacts on Faculty, Departments, and Institutions

- Evaluation Teams at Boise State, Georgia Tech, Michigan

Exit Surveys: 233 VIP Students; 1781 non-VIP Students:

- Ability to work in a Multidisciplinary team:
  \[ t(1981)=4.437, \ p<0.001, \ d=0.313 \]

- 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:
  \[ t(2002)=3.19, \ p=0.001, \ d=0.224 \]
Assessment: Continued

Social Network Analysis of VIP Teams:

• Peer Evaluation Tool Used for Grading Twice a Semester
• Students Indicate Who/How-Often They work with Each Peer
• Linked with VIP Database of Students + Registrar’s Database
• Enables Monitoring of Teams Health
• Helps Identify Best Practices in Team Management for Advisers
• EI Index Computed for Populations of Interest
VIP: Benefits for Students

- Realistic Team Experience
- Opportunity to Learn/Master different Roles/Skills
- In-Depth Experience in their Field
- Long-term Multi-Disciplinary Experience
- Knowledge Exchange across many Boundaries
- Provide a Compelling Reason to be on Campus
- Preparation for Work / Grad School
- Understanding of the Innovation Process
VIP: Benefits for Faculty

- Better Organized, More Effective UG Research
- Continuity of Knowledge and Experience on Team
- Enthusiastic Minds and Hands
- Beneficial Education & Broader Impact for Grants
- Recruiting for Graduate School
- Adds New Dimension to Research Capability
- Peer Leadership and Management Reduces Workload
VIP: Benefits for Universities

- Enhances Student Learning
- Enhances Faculty Research
- Enables New Partnerships
- Creates Multidisciplinary Opportunities
- Compelling Reason to have a Campus
- Everyone Participates in Innovation
- Deepens/Broadens the University Community
The VIP Consortium: 35 Members So Far.....

**United States (24)**
- Arizona State University
- Boise State University
- Colorado State University
- Drexel University
- Florida International University
- *Georgia Tech*[^1],[^AAU]
- Howard University
- Iowa State University[^AAU]
- *Morehouse College*[^URM],[^1]
- New York University[^AAU]
- Notre Dame
- Polytechnic Univ of Puerto Rico[^URM]
- Purdue University[^AAU],[^1]
- Rice University[^AAU]
- Stony Brook University[^AAU]
- Texas A&M University
- UC Davis[^AAU,^URM]
- University of Delaware
- University of Georgia
- University of Hawaii[^URM]
- University of Michigan[^AAU],[^1]
- University of Washington[^AAU]
- VA Commonwealth University
- Virginia Tech

**International (11)**
- Inha University (Korea)
- Malmö University (Sweden)
- Natn’l Dong Hwa University (Taiwan)
- Natn’l Ilan University (Taiwan)
- Riga Technical University (Latvia)
- Universidad del Norte (Colombia)
- Universidad ICESI (Colombia)
- Universidad Mayor (Chile)
- Univ. of New South Wales (Australia)
- University of Pretoria (South Africa)
- University of Strathclyde[^1] (Scotland)

**Pending (6)**
- Georgia State University
- NCA&T University[^URM]
- Reykjavik University
- Tuskegee University[^URM]
- UNICAMP
- Universidad de Chile

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**LEGEND:**

**AAU:** Member Institution (10)

**URM:** Underrepresented Minority Institution (7)

1: Program in place prior to Consortium establishment (6)

**Bold:** State of Georgia Institutions (3)
The VIP Consortium: 2018 Annual Meeting
The VIP Program: Essential Characteristics

• VIP Program Led by Faculty
• Projects embedded in Professors’ Research Efforts
• Large-Scale Projects Lasting Years/Decades
• Multidisciplinary Teams Possible/Encouraged
• Program is Curricular; All Students Graded
• Incentives for Students to Participate for 2+ Years
• Classroom and Meeting Space Supporting Teams
• Learning Outcomes Include Disciplinary and Professional Skills
The VIP Consortium: Essential Characteristics

- All Institutions Have a Professor-Led VIP Program
- Program Must Have Essential Elements of VIP but Adapt as needed to Local Conditions
- Share Resources/Tools/Processes/etc.
- Everyone Contributes What They Can
- Participation in Evaluation and Dissemination
- Publish Papers and Write Proposals Together
What could you do if you had a VIP team?

http://www.vip.gatech.edu

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Definitions/Use of “Innovation” from the OED

• Commerce Definition of Innovation: The action of introducing a new product into the market; a product newly brought on to the market.
  • 1939, J. A. Schumpeter *Business Cycles* I. iii. 84  Innovation is possible without anything we should identify as invention, and invention does not necessarily induce innovation.

• First Usage of the Term Innovation: The action of innovating; the introduction of novelties; the alteration of what is established by the introduction of new elements or forms. †Formerly const. of (the thing altered or introduced).
  • 1553  J. Brende tr. Q. Curtius Rufus *Hist.* x. f. 221v  Perdicas, whose ambicious mynde desirous of innouation, was (he sayde) to be preuented in time.
  • 1561  T. Norton tr. J. Calvin *Inst. Christian Relig.* Table of Contents  It is the duty of private men to obey, and not to make innovation of states after their own will.