Moving from Surviving to Thriving: Transforming the First Year STEM Experience

University of Richmond Integrated Science Experience
“Thriving Quotient”

• **Engaged Learning** – a measure of the degree to which students are meaningfully processing what happens in class, energized by what they are learning, and continuing to think about it outside of class

• **Academic Determination** – a measure of students’ goal-directedness, investment of effort, and regulation of their own learning and use of time

• **Positive Perspective** – a measure of students’ optimism, and explanatory style

• **Social Connectedness** – a measure of students’ involvement in healthy relationships and social support networks, whether on or off campus

• **Diverse Citizenship** – a measure of students’ desire to make a difference in the community around them, as well as their openness to differences in others
Key Aspects

- Faculty Awareness
  - *Vision & Change*
  - High Impact Practices
  - Underserved students in STEM
  - Implicit bias, stereotype threat, fixed vs. growth mindset
Key Aspects

• Faculty Development
  – Workshops on active pedagogy, assessment, metacognition, mindset, and stereotype threat
  – Working with faculty at other institutions through meetings, workshops, etc.
  – Working with colleagues to plan curricula and programs as a team
  – Alumni and student focus groups
Key Aspects for Thriving

• Developing inquiry skills
  – Theme-based course inquiry into real world problems (e.g., challenges of a changing climate, antibiotic resistance, HIV epidemic)
  – Authentic course-embedded research experiences

Graham et al.,(2013) Science, 341
Key Aspects for Thriving

• Integrated & Interdisciplinary Learning
  – Weaving research problem through multiple disciplines
  – Synthesis of knowledge and skills developed to address the problem
  – Increase interdisciplinary and disciplinary understanding
  – Communication of science to variety of audiences
Key Aspects for Thriving

• Engaged Pedagogies
  – Active learning
  – “High course structure” with frequent opportunities for assessment
  – Scaffolded student development

Key Aspects for Thriving

• Cohort-based model
  – Learning Community
  – Community building activities and civic engagement
  – Strong academic support system (e.g., tutors, advisors, mentoring)

Key Aspects for Thriving

- Develop Cognitive and Metacognitive skills
  - Introduce students to Bloom’s taxonomy
  - Work on study skills and learning strategies
STEM Graduates 2010-2013

<table>
<thead>
<tr>
<th>Year</th>
<th>% Traditionally underrepresented of STEM Grads (URM)</th>
<th>% Traditionally underrepresented of All Grads (URM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>6%</td>
<td>10%</td>
</tr>
<tr>
<td>2011</td>
<td>4%</td>
<td>11%</td>
</tr>
<tr>
<td>2012</td>
<td>9%</td>
<td>14%</td>
</tr>
<tr>
<td>2013</td>
<td>7%</td>
<td>16%</td>
</tr>
</tbody>
</table>
Are students who are traditionally underrepresented in STEM interested in STEM at Richmond?

<table>
<thead>
<tr>
<th>Date</th>
<th>% of STEM Interested who are from groups traditionally underrepresented in STEM</th>
<th>% of STEM interested who are Black/African American or Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>28%</td>
<td>16%</td>
</tr>
<tr>
<td>2013</td>
<td>35%</td>
<td>19%</td>
</tr>
<tr>
<td>2014</td>
<td>29%</td>
<td>22%</td>
</tr>
</tbody>
</table>

• ~1/3 of all STEM interested students are from groups traditionally underrepresented in STEM
• In spite of the fact that Black/African American and Hispanic students make up >15% of the STEM interested, at graduation, less than 10% of our STEM graduates are from these groups each year.
HHMI: Call for Inclusion, Persistence, and Community

“HHMI grants have enabled colleges and universities to involve large numbers of underrepresented minority students in student research and other activities... However, their impressive potential still has not been realized as a substantial increase in the number of students from underrepresented groups who go on to careers in science.”
URISE
University of Richmond Integrated Science Experience

Target Populations
under represented in STEM

Black/African-American
Hispanic
Native Alaskan
American Indian
Native Pacific Islander
First generation students
Students of lower economic means

Pre-freshmen Summer
5-week research & developmental experience

Yes
High School courses in physics and calculus?

No
SMART Science, Math and Research Training
20 students

Year 1
IQS Integrated Quantitative Science
20 students

Summer Research Experience

Years 2-4
Integrated Science minor
Scientific Leadership minor
academic year and summer research experiences
mentors/advising focusing on future studies/careers
post bacs and post docs serving as peer mentors to first year URISE students

Post bacs (if appropriate)
Post docs (if appropriate)
URISE Pre-first Year Summer Bridge: Morning Program

• Math and science skill building (e.g., microscopy, solution making, dimensional analysis, statistics, DNA analysis) through discovery-based forensics project
• Community and team building through partnership with Common Ground (diversity and inclusion program)
• Community engagement and social justice component with partners (e.g., UR police, Innocence Project)
• Academic skills assessment workshops
• Science writing and communication workshop
• Course selection and academic advising
• Career development (e.g., alumni STEM career lunches, visit UNC, Duke or UVA graduate and medical programs)
URISE Pre-first Year Summer Bridge: Afternoon Program

- Mentored projects in faculty research laboratories
- Students matched with supportive faculty/peers with similar interests
- Development of research skills
- Connections with STEM peers
URISE Pre-first Year Summer Bridge: Weekend Program

• Students live together in dorms with STEM post-bac as their Resident Assistant
• Saturday excursions to local destinations (e.g., Virginia Beach, Washington D.C.)
• Group dinners, movies, speakers
URISE Student Demographics

- 55 students have completed URISE over the past 3 years (15-20 students/year):
  - 22 men, 33 women
  - 15 First Generation College Students
  - 21 Pell Eligible Students
  - 21 African American/Black Students
  - 14 Hispanic Students
  - 3 Native American/Hawaiian
Some URISE Outcomes

• 100% of URISE students have conducted summer research after their first year; 66% are continuing research in summer after their second year. Others are in internships (e.g., medical, public health).

• 100% of URISE students enrolled in additional STEM courses after completing IQS or SMART.

• 93% of URISE students from the 1st two cohorts have declared STEM majors.

• URISE students report strong self efficacy, feeling more prepared for college classes and research, and a sense of community.
SMART
Science, Math, and Research Training (SMART)

- 2 units class (extended time for math), weekly lab and workshop in fall and spring of 1st year = 4U
- Counts as first course in biology, chemistry and calculus I and II
- Designed for students who did not have opportunities in high school for advanced math (e.g., AP calculus) and who are interested in interdisciplinary and integrated learning with desire to pursue biology, chemistry or biochemistry majors.
- Focus on students traditionally underrepresented in STEM
- Highly structured (pre-class, in-class and post-class engagement)
SMART Course Goals

• Demonstrate ability to use authentic research skills and apply appropriate quantitative reasoning
• Integrate and apply knowledge from biology, chemistry, and math and communicate across disciplines
• Express increased confidence in science and math
• Ability to understand HOW they learn and know a variety of problem-solving strategies
• Understand and apply material equivalent to Bio 199, Chem 141, Calc I and Calc II and mastery of a subset of core concepts from each course.
HIV: Mechanisms and Solutions
Afryea Henderson, Ed Provencher, Lena Dang, Maria Florentin
University of Richmond, VA 23173

Introduction
Human immunodeficiency virus (HIV) is a retrovirus that infects 33 million people. Approximately 90% of these people live in developing countries such as West Africa where medical care is not readily available. On the other hand, there have been cases where, even after multiple exposures to HIV, an individual remained HIV negative. This was determined to be the result of a mutation known as CCR5-Δ32. This mutation evolved in our ancestors in northern Europe centuries ago. In order to combat HIV, it is vital to first understand the virus and its mechanisms of infection. After gaining an understanding of these mechanisms, it becomes possible to pursue solutions to this pandemic.

Utilizing ELISA Test for Steve’s Diagnosis

○ By the time Steve tested positive for HIV, he was already experiencing full-blown AIDS. Due to poor prognosis, it prompted friends that may have come in contact with the virus through Steve to seek testing. Runner #1 tested negative, however when Runner #2 began exhibiting symptoms after 6 months his results changed from negative to positive.

Determining Steve’s Viral Load with qRT-PCR

Figure 2. A. Quantitation graph illustrates the fluorescence intensity vs. cycle number of each standard throughout the PCR amplification process. Line above x-axis is the threshold indicator for fluorescence. B. Illustration of standard curve of known dilutions of HIV Envelope gene. C. Formula used for calculating efficiency, E, the percentage that the standard curve indicates the amount of product increasing with each cycle. Calculated E equated to 1.01, which is considered reliable. D. Typical course of HIV infection with point plotting Steve’s calculated viral load of 113,279 Env copies/mL.

Figure 3. Phage attaching to bacteria.

Figure 4. A. Structure of T4 phage before contraction. B. Structure of T4 after contraction. C. Illustration of the longitudinal fiber.

Figure 5. A. The rate of neutralization of phage is proportional to the percentage not neutralized. B. When the differential equation is solved, n(t) equals the percentage of phage virions that were prevented from infecting the bacterial cells. C. The graph of the amount of phages neutralized after different times of incubation.

Viral Investigation

Experiment

Question: Are combinations of monoclonal antibodies more effective at neutralizing phages than single monoclonal antibodies alone?

Results: Our results indicate that single monoclonal antibodies do little to inhibit T4, however, another group within our lab found that a specific combination of the monoclonal antibodies may effectively neutralize the T4 phage.

Figure 6. A. HIV Protease breaking up polyprotein chain. B. Comparison of HIV Protease and Pepsin. C. Comparison of Inhibitors (Ritonavir & Lopinavir). D. Beer’s Law used to determine absorbance of Chromophore in Pepsin. E. Illustration of Substrate Cleavage Rate with various Substrate volumes and inhibitors.

Experiment 3

Can Pepsin be inhibited by HIV Protease inhibitors?

Figure 7. A. gp120 binding to a Wild type CCR5. B. 32bp deletion that constitutes the CCR5Δ32 mutation, rendering that binding is not neutralized by HIV when attempting to infect CD4+ cell. C. The Poison Distribution is a formula used to calculate the probability of an event occurring in a fixed interval of time with an own mutation rate. It was estimated that 686,977 years had occurred since the development of the CCR5Δ32 mutation. D. Results from amplification of CCR5 region and electrophoresis.

Conclusion

Many tests can be conducted to find the presence of HIV, such as the ELISA test. Other experiments such as Real Time PCR illustrates viral load in a patient who is HIV positive. Understanding the host specificity of Viral Phage Infectivity and antibodies’ ability to neutralize phage can potentially help find different mechanisms of HIV prevention. Standard methods of HIV-1 treatment can become problematic when drugs such as Lopinavir and Ritonavir are used to decrease HIV Protease cleavage because these drugs could also inhibit the ability of Pepsin to cleave proteins in the stomach. So far, only one mutation, CCR5Δ32, has been discovered that leads to resistance to HIV.

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Department of Biology University of Richmond, Richmond, VA 23173

Viral Phage Infectivity and Antibodies’ ability to Neutralize Phage can Potentially Help Find Different Mechanisms of HIV Prevention.

Distribution is a formula used to calculate the probability of an event occurring in a fixed interval of time with an own mutation rate. It was estimated that 686,977 years had occurred since the development of the CCR5Δ32 mutation. D. Results from amplification of CCR5 region and electrophoresis.
Some SMART Outcomes – 3 yr data

- 100% of students enrolled in SMART finished the 2 semester course, 100% conduct summer research; students report high self efficacy and engagement
- 98% of students completing SMART take additional STEM courses
- 80% who have declared majors are STEM and 95% STEM major or minor
SMART: Classroom Undergraduate Research Experience Survey (CURE)

Figure 2. The figure illustrates the mean ratings by students of gains in 21 areas, corresponding to the areas above. As these same items are evaluated by students who participate in summer undergraduate research, the recent results of the Summer Undergraduate Research Experience (SURE) survey are presented for reference. Also presented (green squares) are the overall mean ratings by the reference cohort of students who completed the CURE survey in the academic year of 2013-2014. The vertical lines around the SURE means represent 2 standard errors above and below. Note: Data from students who completed the pre-course survey and those who did not are indistinguishable.
SMART Quotes

“Well, now I have a better understanding on how much scientists can make a difference for real world issues, and how much we need more brilliant scientists. I also understand how much time and effort it takes to discover new things and that failure is a big part of science but also an important part.”

“In high school we just learned the material and crammed for the test in order to get a good grade. There was no desire to study the information in order to learn and use it in the real world. But this course has taught me that I need to learn the information in order to use it in my future career. By doing more advanced and current research, I developed a passion for learning in the hopes that in my future career I will be able to utilize this knowledge. I want to have as many skills and as much knowledge about the sciences as possible so I can have a wide range of opportunities available to me.”

“I feel very confident talking to people about science with people after doing my first poster presentation. At first, I was nervous of course, but then all of the related material that we discussed during the labs began to start flowing out naturally.”

“I feel a lot more hopeful about things I can do with a science degree. I had previously thought that my only interest was in medicine but I am finding that I have an affinity for the chemistry aspect of things.”
SMART Student’s Perspectives

• “In SMART we went beyond the material in the textbooks and applied it to our everyday lives. We were able to learn science and math and actually see how the subject relates to the world, which is something I will be able to take onto my other classes. This class has prepared me to take on upper level classes with confidence.”

• “The connection between biology and calculus in this program is very strong. We analyzed a lot of our data generated in bio labs during our calc workshops. This really helped me to synthesize calc techniques with analyzing and interpreting data. I also developed strong computer skills through using excel regularly. I am able to look at a set of data and understand what the numbers means, and how I can use certain equations and graphing techniques to further interpret them.”

• “This class gave me the confidence and mindset to connect patterns and analyze data. These skills can be carried to any class science or non-science. Also, the scientific mindset allows me to make conclusions and carry out experiments like I've never been able to before.”