



The Triad Approach: Stimulating learning in the undergraduate classroom

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Poster 470B

The Allied Genetics Conference
TAGC, April 2020

Abstract

National education efforts emphasize the need to practice the process skills of science rather than strictly focus on discipline-specific content. Developing these skills early within undergraduate education promotes cognitive progression and conceptual application; however, they require deliberate cultivation, particularly with early-stage scientists. We developed the Triad Approach for use in the undergraduate genetics classroom as a departure from traditional lecture. **Our hypothesis was that the Triad Approach will result in measurable learning gains in critical thinking skills and scientific literacy.** The Triad leverages active-learning through iterative cycling of lectures, journal clubs, and case studies on specific genetics course related themes. Thus, students observe, analyze, and apply content three times from unique perspectives, resonating with multiple learning styles. Students were directly assessed on comprehensive problem sets, analysis of case studies, and primary literature interpretations. Direct and indirect measures, self-assessments and student surveys, suggest a marked improvement in learning and scientific literacy. Students' averaged 0.55 normalized gains in quantitative knowledge (modeling); 0.33 gains in critical thinking; 0.40 quantitative reasoning; and a 0.63 gain in analytical genetic skills (-omics). Similarly, comparison of cumulative pre-course GPA to overall course performance identified students who over or under performed in the Triad Approach compared to traditional learning strategies. Notably, compared to students across the entire university, we see higher reported means for critical thinking and learning. Together, **we present the Triad Approach as an alternative teaching strategy, which leverages contemporary tools, to stimulate student learning and skill development.**

Student Feedback

unique
helpful
interactive
lecture
context
higher-level
better
valuable
beneficial
synthesis

"I really appreciated the method of learning because I could not only see growth in my abilities, but I could also get a better understanding of the material and RETAIN it, rather than brain dump it after the test."

"It also encouraged quick synthesis of information and thinking on one's feet, which is a valuable skill to learn."

"I loved the structure of this class. It gave us the freedom to learn and deep dive into topics. It made learning more enjoyable and I found it beneficial that we actually applied concepts instead of memorizing abstract ideas."

Results

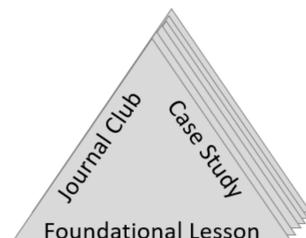


Figure 1. Components of the Triad Approach

The Triad Approach to learning is an iterative cycle consisting of three distinct lessons. The first is an instructor-led, traditional, style of learning where faculty present foundational knowledge relevant to the course topic. The second lesson is where students analyze and present primary scientific literature which relates to the foundational lesson. Their third lesson involves students analyzing, synthesizing, and reporting on a case study, also related to the foundational lesson. This cycle is repeated over the course of the semester.

Table 1. Reported gains from student surveys

| Survey Area (0-8 ranking) | Normalized Gain (ave) |
|--|-----------------------|
| 1. Quantitative knowledge (modeling) & reasoning | 0.55 |
| 2. Scientific process & critical thinking | 0.33 |
| 3. Quantitative reasoning (evaluate) & mathematics | 0.40 |
| 4. Genetic analysis (BLAST-Basic Life Science Associated Skills & Tasks) | 0.63 |
| 5. Lead scientific discussions on genomics | 0.70 |

Students completed pre- and post-course enumerations of their relative abilities on questions regarding each area on a scale of zero to eight. The aggregate summation of questions supporting each topic were calculated and averaged for the class. Normalized gains were calculated based on these averages [(post-pre)/(100%-pre)]. All values were statistically significant based on a t-test with 95% confidence interval (n=36).

Table 2. Genetic students compared to Academy wide surveys

| | Course | | Academy |
|--|--------|------|---------|
| | Mean | SD | Mean |
| My scientific communication skills have greatly improved | 4.83 | 0.37 | |
| My critical thinking ability increased | 5.00 | 0.00 | 4.20 |
| My creativity and ability to take intellectual risks increased | 4.50 | 0.76 | 4.07 |
| Students were responsible for their own learning | 4.50 | 0.50 | 4.52 |
| Effective learning techniques were used (in- and out-of class) | 4.67 | 0.47 | 4.27 |
| My fellow students contributed to my learning | 4.50 | 0.50 | 4.08 |
| My motivation to learn and continue to learn has increased | 4.67 | 0.47 | 3.96 |
| The assignments evaluated my understanding of the material | 4.33 | 0.75 | 3.84 |

Students completed individual surveys for each of these questions for all courses at the Academy (scores ranging from strongly disagree [0] to strongly agree [5]). Responses, specifically pertaining to this course (n=36), were compared to the Academy mean, which includes students across all courses offered during that semester. Notably, motivation to learn and understanding of the material were above the Academy mean at 4.67 and 4.33, respectively.

Figure 4. Comparing CQPA to Course Average

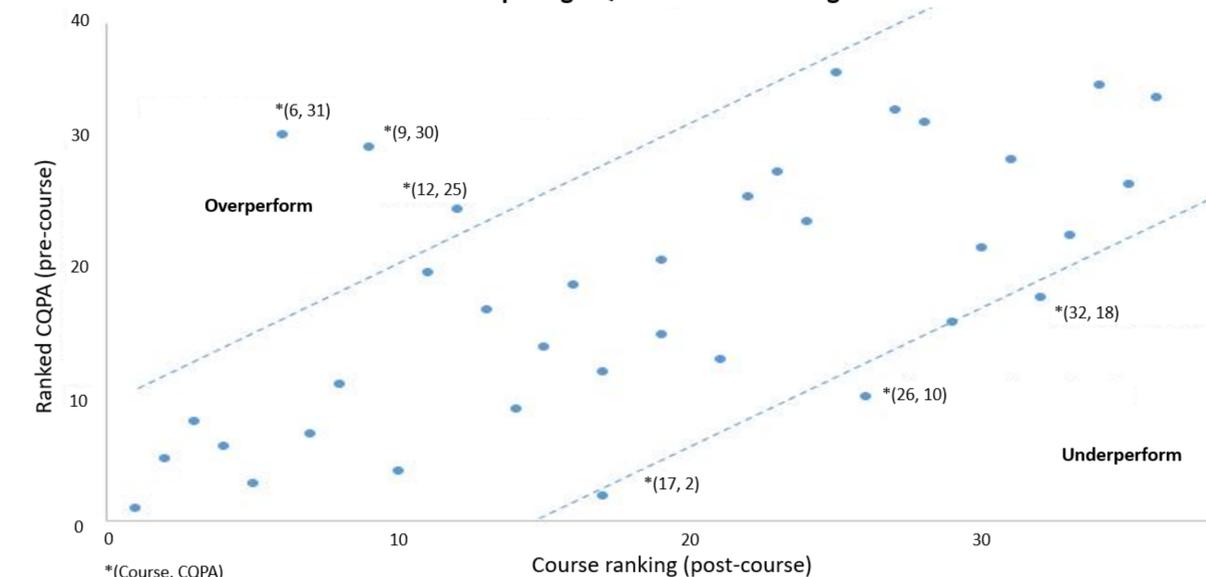


Figure 4. Predicting course performance based on pre-course CQPA

An order of merit listing (OML) was prepared at the beginning of the course, ranking individual students from 1 through 36 based on cumulative quality point average (CQPA). Similarly, end-of-course averages were ranked within the cohort. These values were compared to identify students who over or underperformed based on incoming CQPA. In general, CQPA related to course performance. Interestingly, there are three cadets who "over-performed" and three who "under-performed". Tracing this back to their post-course survey questions, cadets who over-performed indicated that they appreciated or learned more from the conceptual application of course material. Similarly, those who under-performed indicated that they preferred a more traditional, lecture and exam-based, course (n=36).

Our Triad Approach to Learning suggests:

- Student achieve measurable gains in critical thinking skills & scientific literacy
- These gains translate to increased skills compared to their Academy student peers
- Learning styles used within the Triad will appeal to a wide-range of learners

Follow-on experiments:

- While these data represent our pilot study during one semester (AY19), we are continuing the assessment during the current course offering in AY20.

We would like to acknowledge the assistance of member of the Interdisciplinary Chemistry, Engineering, & Biology Education Research Group (ICEBERG) for their critical review of this effort and the US Military Academy for financial support. All work completed under Human Research Protection (HRP 19-044). The views expressed in this poster are those of the authors and do not reflect the official policy or position of the United States Military Academy, Department of the Army, the Department of Defense, or the U.S. Government.