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Active Immersion in Scientific Literature: Gateway to Critical Thinking

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Active Immersion in Scientific Literature: Gateway to Critical Thinking

Diane C. Tucker, Ph.D., Alan W. Eberhardt, Ph.D., Joe L. March, Ph.D.
Science and Technology Honors Program
Fall 2010 Enrollment ~17,500

Biomedical research university
• Top 20 in NIH funding nationally
Science and Technology Honors Program

• Thematic honors program, building upon UAB’s strength in biomedical research
• Program began in Fall 2005
UAB: Honors Options that “Fit”

- University Honors Program
- Science and Technology Honors Program
- Global and Community Leadership
- Experiential Learning Scholars Program
Scientific Leaders of the Next Generation

**Mission:**
Prepare students to be the *scientific leaders* of the next generation
Scientific Leaders of the Next Generation

Mission:
Prepare students to be the scientific leaders of the next generation
Beyond doing to thinking... How to teach scientific thinking?

- Crucial foundation- want students to be intellectual participants in research
- Scientific literature
  - Barrier
  - Potential window to scientific process
- Sci Tech often begin mentored research freshman year
CREATE

- **Consider**
- **Read**
- **Elucidate hypotheses**
- **Analyze data**
- **Think of the next**
- **Experiment**

- **Concept map**
- **Cartoon methods**
- **Annotate figures**
- **Propose next experiment**

_Hoskins & Stevens, Adv Physiol Educ 33: 17–20, 2009_
Our Challenge

CREATE (Hoskins et al.)

- CREATE conceived as 400 level, 3 hr, semester-long cell biology course
- “less is more” philosophy
- Examine series of 4 papers from single lab during semester
- Emphasis on students constructing their knowledge

Sci Tech application

- Freshman 1 hour honors Introductory Seminar
- Students in all science/engineering majors
- Baseline scientific knowledge variable
Teachers as Learners

- Invited Dr. Hoskins to UAB for 2 day workshop
- Seminar
- Workshop
  - Experiential using “training wheels” paper
Adapting CREATE for Sci Tech Freshmen

• Learning goals of Introductory Seminar
  • Understand “what is research” by exploring research labs at UAB
  • Link lab research to overall scientific questions
  • Develop skills needed for comprehensive reading of scientific papers
  • Experience working in a team environment
Adapting CREATE

• “Training wheels” paper:

• Read as group
  • Concept maps of introductory concepts
  • Cartoon of methods
  • Annotate Figure 1

• Paper from UAB research lab
Concept Maps: Cell Phone Use while Driving
Cartoon Method

Response times to breaking for red lights were recorded during both the single task phase and the dual task phase. The amount of red lights missed was also recorded during the two phases.
Method Cartoon
Annotating Figures

- Connect method with data
- Consider alternative methods to present data
- Interpret graph
Examine Research of UAB Scientist

- Upper class STH student as “research liaison”
- 3 freshmen as team: matched topic to interest
- Presentations
  - Research question and 3 key terms
  - 3 minute video about lab- interview mentor/student
  - *5 weeks... Training wheels...*
- Key figure in journal article
  - Identify research paper
  - Apply CREATE skills to understand key figure
Applying CREATE Skills

• Concept map of Introduction
• Chose 1 “key figure”
  • Identify methods used to generate data in figure
  • Annotated figure to explain to class
    • Broadened impact... communication challenge...

• Student groups needed individual coaching to reason through the data in the key figure and decipher the relevant methods
## Pre- and Post Surveys

**How confident do you feel about each of the following?**

1. Not at all  
2. Somewhat  
3. Moderately confident  
4. Very confident  
5. Completely confident

### Statement

<table>
<thead>
<tr>
<th>Statement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding of the research process</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Readiness for more demanding research</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Understanding how scientists work on real problems</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Learning lab techniques</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Tolerance for obstacles</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Learning to work independently</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Ability to analyze data</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Understanding how knowledge is constructed</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Becoming part of the learning community</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

**Overall, how satisfied are you with your experience as a Science and Technology Honors student?** (Rate 1-10, 10 = completely satisfied.)

**Please answer the following questions:**

- How confident are you about discussing scientific research?  
  - Confident  
  - Somewhat Confident  
  - Not at all confident

- How confident are you about reading and interpreting scientific literature **within your major**?  
  - Confident  
  - Somewhat Confident  
  - Not at all confident

- How confident are you about reading and interpreting scientific literature **outside your major**?  
  - Confident  
  - Somewhat Confident  
  - Not at all confident

- How confident are you about defending your opinion about a science related question during a discussion **with your peers**?  
  - Confident  
  - Somewhat Confident  
  - Not at all confident
Example Results – Areas with Significant Improvement

Course goals

- Understand research process
- Readiness for demanding research
- Understand how scientists think
- Discuss scientific research
- Read and interpret scientific literature within major

Pre Data vs. Post Data
Example Results – No Improvement

Suggest honest student evaluation

- Ability to analyze data
- Become part of learning community
- Clarification of career path
- Believe interdisciplinary approach is beneficial

Pre Data
Post Data
Asking Good Questions

- Students were required to prepare questions following student presentations

Summary and Definition Questions
- what is (are)...
- who...
- when...
- how much...

Analysis Questions
- how...? why...?
- what are the reasons for...
- what the types of...

Hypothesis Questions
- if occurs, then what happens...
- if had happened, then what would be different...
- what does theory predict will happen...

Evaluation Questions
- is...good or bad...
- correct or incorrect...
- effective or ineffective...

4 groups based on Bloom’s
Student Questions: Definition (what is, who, how many)

- What's chromatin?
- Which specific gene methylations are the lab examining?
- What is the photo-resist spin-on technique?
- What is in the pellet that they would like to study?
- What exactly is the gel used?
- What is an fMRI?
Student Questions: Analysis

• How is nicotine currently believed to affect the brain?
• How does methylation affect gene inhibition?
• How is the mutation forced?
• What kind of experiments are they conducting on the mice to determine if they have retinal failure?
• How can motivation be quantified?
Student Questions: Hypothesis

- Does he actually create heart disorders to see how they affect the heart?
- Is stress from mental activities equal to stress from physical activity?
- Is there a difference in how genes are expressed depending on whether methylation occurs to DNA or the histones?
- Is there a specific time where knock in genetics is more effective in this study?
Student Questions: Evaluation

- Would discoveries from this research potentially allow you to identify more factors of poor vision and blindness?
- You have to elevate your heart rate to stay healthy, when do you know it is too much?
- Histone-methylation's long-term effects are being observed, but what are the immediate effects?
- What is practical application of this research?
• **Trends:**
  - Analysis questions exceeded 50% at each sampling
  - Mid term: Definition questions were less than 20%. Nearly 25% were Hypothesis/Evaluation
  - End of term: Definition questions were less than 10%, while Hypothesis/Evaluation questions approached 40%
Summary

• Students gained confidence in reading and discussing scientific literature
• Students gained confidence in understanding how scientists think about problems
• Students progressed toward asking “better” questions, as defined by Bloom’s Taxonomy
Conclusions

- Hoskins’ CREATE method can be adapted to
  - Interdisciplinary context
  - Freshmen honors students
  - Reduced scope

- Impact on
  - Student confidence in reading and understanding scientific literature
  - Quality of questions students ask
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Laboratory training courses

Spring semester freshman year
Hands-on experience with foundational methods

• Biotechnology
• Engineering Design and Analysis
• Chemical Analysis Techniques
Finding Mentors: Quick Connections

- Scientific “speed dating”
Mentored Research Experience

- Individualized research experience with faculty mentor
  - Nanomaterials
  - Gene therapy
  - fMRI brain imaging
  - Global Observation Laboratory
  - Neuroscience

- Honors Thesis
  - Journal article format
  - Goal:
    - Present at national meeting
    - Publish results
Scholarly Learning Community