### SUMMARY

1. **PURPOSE.** To provide security and policy review on the document at Tab 1 prior to release to the public.

2. **BACKGROUND.**

Authors: Westmoreland, David.

Title: Assessment of scientific reasoning as an institutional outcome.

Release Information: This presentation will be given at the Scholarship of Teaching & Learning Commons, 30 Mar - 01 April 2016, Savannah, GA

3. **DISCUSSION.** N/A

4. **VIEWS OF OTHERS.** N/A

5. **RECOMMENDATION.** Sign coord block above indicating document is suitable for public release. Suitability is based solely on the document being unclassified, not jeopardizing DoD interests, and accurately portraying official policy.

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Senior Military Faculty and Deputy for Research

Tab

1. Abstract
2. Presentation slides
The US Air Force Academy has established 9 institutional outcomes, each of which is assessed by a team of 5-10 faculty and staff members with expertise in the outcome domain. Student achievement of the "Scientific Reasoning and Principles of Science" was assessed in the 2012-13 academic year by sampling 203 students distributed across freshman-to-senior class years. Two assessment instruments were used: (a) an in-house survey of student understanding of the Nature of Science, and (b) the Lawson test of scientific reasoning. Students showed statistically significant gains in both scores between the sophomore and junior years. Student understanding of the Nature of Science did not differ by program of study, but students in the basic sciences and engineering scored significantly higher than students in the humanities on the scientific reasoning assessment. Overall, students were weakest when answering questions related to (a) proportional reasoning, (b) isolation of variables, and (c) if-then reasoning. These findings are being incorporated into a redesign of the core curriculum to enhance continuity among science courses in presenting the Nature of Science, and coordination among basic sciences course directors to align efforts to teach scientific reasoning.
Assessment of Scientific Reasoning as an Institutional Outcome

01 April 2016

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The Need for Scientific Literacy

The ADE 651 is a "remote portable Substance detector"
$10K – 60K per unit
The Need for Scientific Literacy, Part II

Courses that are Explicitly Designed to Emphasize Science

**Freshman Yr**
- Beh Sci 110
- Chem 100
- Physics 110

**Sophomore Yr**
- Chem 200
- Physics 115

**Junior Yr**
- Beh Sci 310
- Biology 315

**Senior Yr**
- Mgt 400
Approach of the Assessment Team

- Semi-random sample to assess:
  - Comprehension of the scientific method as a way of understanding the natural world (Instrument A)
  - Application of scientific reasoning to solve questions (Instrument B)

Instrument A
(Score ranges from 0 – 12)

Designed to assess whether students comprehend the fundamentals of science as a way of thinking:

- What is the goal of science?
- What are the limitations of scientific inquiry?
- How are the principles of empiricism, skepticism, and rationalism applied?
- What is the distinction between fact, law, theory?
Instrument B
(Score ranges from 0 – 12)

Designed to assess whether students effectively apply scientific reasoning to solve problems. Assesses:
- Proportional reasoning
  (example \(\rightarrow\))
- Correlational reasoning
- Probabilistic prediction
- Isolation of variables
- Hypothetico-deductive (If, Then) reasoning
- Conservation of matter

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Jan 2013

- We sampled cadets taking Physics 100, Chem 200, Biology 315, and Strategic Studies 416
- \(N = 203\) cadets
- Data recorded:
  - Scores on both instruments
  - Class year
  - Academic division
  - Core, Maj, Cum GPA
What Happens as Cadets Progress Through the Curriculum?

Conceptualization of Science as a Way of Knowing

Scientific Reasoning/Problem solving

Does Academic Division Matter?

Conceptualization of Science as a Way of Knowing

Scientific Reasoning/Problem solving
Does Core GPA Correlate?

Conceptualization of Science as a Way of Knowing ($r = 0.335$)  
Scientific Reasoning/Problem solving ($r = 0.235$)

Which Factors are Significantly Related to Assessment Scores?

<table>
<thead>
<tr>
<th>Conceptualization of Science as a Way of Knowing</th>
<th>Scientific Reasoning/Problem solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class year $P = 0.02$</td>
<td>Class year $P = 0.03$</td>
</tr>
<tr>
<td>Division $P = 0.29$</td>
<td>Division $P = 0.09$</td>
</tr>
<tr>
<td>Core GPA $P = 0.01$</td>
<td>Core GPA $P = 0.25$</td>
</tr>
<tr>
<td>Major GPA $P = 0.42$</td>
<td>Major GPA $P = 0.69$</td>
</tr>
<tr>
<td>Class Yr*Division $P = 0.14$</td>
<td>Class Yr*Division $P = 0.21$</td>
</tr>
</tbody>
</table>
Summary of Assessment Findings

- Cadets show a significant improvement in Conceptualization of Science and Scientific Reasoning between 3-degree & 2-degree years
- Conceptualization of Science: Firsties and 2-degrees score low, regardless of Division
- Scientific Reasoning: Firsties and 2-degrees score about the same as reported in another study;
- Cadets in science-focused Divisions tend to have better skills in scientific reasoning and problem solving

Summary con’t.

- Core GPA correlates weakly with both assessment scores
A WAY FORWARD
Conceptualization of Science

• Biology 480
  — Explicit instruction on science as a way of thinking is effective

• The Core
  — Coordinate the core science classes to introduce and reinforce the fundamentals of scientific thinking

A WAY FORWARD
Scientific Reasoning

• Our students are weakest on
  — Proportional reasoning (57.5% correct)
  — Isolation of variables (47% correct, ex: →)
  — If, then reasoning (35% correct)