Engaging Faculty in Assessing Critical Thinking Using the CAT Instrument

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Tennessee Tech University

Texas A&M Assessment Conference, 2014

Partial support for this work was provided by the National Science Foundation’s TUES Program under grant 1022789.

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Disclaimers

- The Development of the CAT Instrument and the National Dissemination of the CAT Instrument is supported by the National Science Foundation.

- Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
Workshop Goals

- Give institutions hands-on experience with the CAT instrument.
- Explore how the CAT can be used to encourage more effective practices within disciplines.
- Discuss potential ways to use the CAT for assessment.
Workshop Materials

Yours to Keep

- Training Manual
- Technical Information
- Overview CD
- Sample Institutional Reports

Secure Items (not to be taken)

- CAT Test with Sample Responses
- Scoring Guide
National Advisory Board

Dr. John Bransford
Professor Emeritus  University of Washington

Dr. Donald Deeds
Professor of Biology  Drury University

Dr. Peter Ewell
Vice President  The National Center for Higher Education Management Systems

Dr. Michael Grant
Associate Vice Chancellor  University of Colorado

Dr. Gregory Light
Director Searle Center for Teaching Excellence – Northwestern

Dr. Patricia Turner
Vice Provost UCLA
National polls indicate over 90% of the faculty in this country think critical thinking is the most important part of undergraduate education.

Derek Bok, 2005
President Emeritus of Harvard University
Importance of Critical Thinking

Explosion of Information

Internet

E=MC²
Email
MySpace
Wikipedia
Facebook
Phone Apps
Augmented Reality
MOOCs
Blogs
Wikipedia
Books
Radios
Magazines
Journals
Television
The Changing Nature of Education

Remembering Information

Finding Relevant Information

Understanding & Evaluating Information

Using Information Effectively
Information and the Internet

95% of College Students use Google to Search for Information in Course-Related Research

People are more likely to believe something on YouTube than from the CDC

71% of Adults Use the Internet for Healthcare Information
What is Critical Thinking?

Classic Emphasis

Evaluate Arguments and Conclusions

Reasoning
What is Critical Thinking?

Classical Emphasis

Evaluate Arguments and Conclusions

Reasoning

Expanded Contemporary Emphasis

Evaluate Ideas And Plans

Problem Solving

Communication

Creativity

Evaluate One’s Own Understanding

Life-Long Learning Skills
Bloom’s Classic Taxonomy

- Evaluation
- Synthesis
- Analysis
- Application
- Comprehension

Information (rote retention)

Critical Thinking
**Agreement on what is not Critical Thinking**

<table>
<thead>
<tr>
<th>*NSSE Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2a) Memorizing facts, ideas, or methods from your courses and readings so you can repeat them in pretty much the same form.</td>
</tr>
</tbody>
</table>

*National Survey of Student Engagement*, Indiana University
**NSSE:** Coursework emphasizes: Memorizing facts, ideas, or methods from your courses and readings

![Student Responses Nationally](chart.png)
Why Assess Critical Thinking?

Need to Measure Success for Accountability

Assessment Drives Improvement Efforts

How We Assess - Determines What Students Learn
History of CAT Development

Preliminary Work
At TTU 2000 - 2004

Refine Test with National Input
Expand National Dissemination
& Support Assessment in NSF Projects
Over 200 Institutions Collaborating
Designing the CAT Instrument

Faculty Driven: High Face Validity Involved in Scoring

Construct Validity: Learning Sciences

Engaging for Students

Reliable & Consistent Scoring Essay Responses
Skills Evaluated by CAT Instrument

**Evaluating Information**
- Separate factual information from inferences.
- Interpret numerical relationships in graphs.
- Understand the limitations of correlational data.
- Evaluate evidence and identify inappropriate conclusions.

**Creative Thinking**
- Identify alternative interpretations for data or observations.
- Identify new information that might support or contradict a hypothesis.
- Explain how new information can change a problem.

**Learning & Problem Solving**
- Separate relevant from irrelevant information.
- Integrate information to solve problems.
- Learn & apply new information.
- Use mathematical skills to solve real-world problems.

**Communication**
- Communicate ideas effectively.
Faculty Evaluations of Question Validity

![Bar chart showing faculty evaluations of question validity. The x-axis represents questions numbered from q1v to q15v, and the y-axis represents percent. The chart indicates that all questions have high validity ratings, with most questions falling between 90% and 100% validity.](chart_image)
## CAT Statistics

<table>
<thead>
<tr>
<th></th>
<th>ACT</th>
<th>SAT</th>
<th>Academic Profile</th>
<th>Grade Point Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT</td>
<td>0.501*</td>
<td>0.516*</td>
<td>0.562*</td>
<td>0.295*</td>
</tr>
</tbody>
</table>

**CCTST**

(California Critical Thinking Skills Tests)

<table>
<thead>
<tr>
<th></th>
<th>CCTST</th>
<th>CAAP Critical Thinking Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT</td>
<td>0.645*</td>
<td>0.691*</td>
</tr>
</tbody>
</table>
CAT Results with 2005 NSSE
(National Survey of Student Engagement)
Multiple $R = 0.490$
(explains 24% of variability in CAT)

<table>
<thead>
<tr>
<th>NSSE Question</th>
<th>Beta Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2a) Memorizing facts, ideas, or methods from your courses and readings so you can repeat them in pretty much the same form. <em>(negative relationship)</em></td>
<td>$-0.341 **$</td>
</tr>
<tr>
<td>(3b) Number of books read on your own (not assigned) for personal enjoyment or academic enrichment.</td>
<td>$0.277 **$</td>
</tr>
<tr>
<td>(11e) Thinking critically and analytically &amp; (11m) Solving complex real-world problems</td>
<td>$0.244 **$</td>
</tr>
<tr>
<td>(7h) Culminating Senior Experience (thesis, capstone course, project, comprehensive exam, etc.)</td>
<td>$0.231 *$</td>
</tr>
</tbody>
</table>

* Significant at .01 level
** Significant at .001 level
CAT features

- One hour exam
- Mostly short answer essay
- Faculty scored in workshops
- Detailed scoring guide
- Sensitive to course effects
- Reliable
- Valid
A government scientist believes that an ingredient commonly used in bread causes criminal behavior. To support the hypothesis the scientist notes the following evidence.

- 99.9 percent of the people who committed crimes consumed bread prior to committing crimes.
- Crime rates are extremely low in areas where bread is not consumed.

Do the data described above strongly support the scientist’s hypothesis? Yes ___ No___

Are there other explanations for the data besides the scientist’s hypothesis? If so, describe.

________________________________________________________________________________________

What kind of additional information or evidence would help evaluate the scientist’s hypothesis?

________________________________________________________________________________________
Ensuring Reliability of Scoring

- Detailed Scoring Guide
- Integrated Training/Scoring
- Multiple Scorers Each Question
- Train-the-Trainer Workshops
- Scoring Calibration
Mini-workshop vs. Standard Training

**Mini-workshop**
- Examine Sample Student Responses
- Use Scoring Guide

**Standard Train-the-Trainer Workshop**
- Score Real Student Tests
- Use Scoring Guide
- Use Multiple Scorers
- Deal with Ambiguous Responses
CAT Test with Sample Student Responses
Effective Practices Are A Moving Target

Video
CAT as a Catalyst for Improvement

Closing the Loop in Assessment and Quality Improvement

Assess Student Performance

Improve Student Learning

Increase Faculty Awareness of Student Weaknesses (Faculty Participate in Test Scoring)

Increase Faculty Awareness of Effective Practices
Faculty Are Using the CAT To

- Identify Student Weaknesses
- Improve Course Assessments
- Identify Strategies for Improving Critical Thinking
Identify Relevant Skill Areas on Checklist
Using the CAT as a Model for Developing Better Discipline Specific Assessments

Provide alternative interpretations for information or observations that have several possible interpretations.

Identify additional information or evidence needed to evaluate the alternative interpretations.

Patterns of Data  Historical Events  Literature
"If We Must Die" is a poem about having valor on the battlefield. The speaker is a military commander rallying his troops before a big battle. This is evident by looking at the war-like language McKay uses throughout the poem, such as "let us nobly die," "we must meet the common foe," "our precious blood," and "dying, but fighting back."

1. To what extent do the quotations provided support the student's interpretation of the poem?
2. Provide an alternative interpretation of McKay's use of war-like language.
3. Identify 3 types of additional information that would help you investigate McKay's intent in writing the poem and explain why each source would be helpful.

J. Todd, Xavier University
Using Headlines to Develop Discipline

Analogs

Girls Who Play Soccer Have More Success in STEM Fields

Consuming High Fat Dairy Products Leads to Lower Obesity than Consuming Low Fat Dairy Products

Frequent Reliance on Social Services Yields Shorter Life Span

Eating Fast Food Leads to Depression
Skill Set 2: Encouraging Effective Course Assessments

- Separate relevant from irrelevant information when searching for information to solve a real-world problem.

- Identify and explain the best solution for a real-world problem using relevant information.

- Explain how changes to a real-world problem situation might alter the recommended solution.

Selecting New Lab Equipment  Solving a Community Problem – Feral Cats  Designing a Set For a Play
Discipline Specific Assessments Modeled on the CAT

- Are Used in a Wide Variety of Courses
- Can be Integrated with Portfolios
- Are Used to Evaluate Real-World Problem Solving
The CAT has Been Used with Many High Impact Practices for Teaching Critical Thinking.

- Real World Problems
- Service Learning
- Original Research
- Critical Thinking
- Case Studies
- Debates
- Simulations
What Are We Learning From National Use of the CAT

- Faculty Involvement is Beneficial
- Strategies for Improving Critical Thinking
- Faculty Can Improve Course Assessments
SUCCESSFUL PROJECTS
Some Examples of Projects that have Improved CAT Scores

Under Construction

Clemson University

NSF TUES (CCLI) Project #0837540. Development of an Inquiry-Based Cell Biology Laboratory with Emphasis on Scientific Communication Skills. PI: Dr. Lesly Temesvari (LTEMESV@clemson.edu) or Dr. Terri Bruce (terri@clemson.edu).

This project involved the development of a new cell biology laboratory course that emphasized critical thinking, effective writing and communication, and ethical reasoning. The new course used an inquiry-based pedagogic strategy allowing students to design and perform experiments in the context of mini research projects. Students also gained experience in communicating their findings through poster/oral presentations and through the writing of manuscripts in standard journal format. As a part of the scientific inquiry and communication processes, students also engaged in the discussion of the ethics of scientific communication.

Duquesne University

NSF TUES (CCLI) Project #717685. A Model for Incorporating Application-Based Service Learning in the Undergraduate Science Curriculum. Dr. Nancy Trun (PI) trun@duq.edu, Dr. Lisa Ludvico & Dr. Becky Morrow (Co-PIs).

http://www.scienceresearch.duq.edu/bio/biofac/ntrun/ABSL/index.html

Application Based Service Learning (ABSL) is a pedagogy that we are developing to address the need for novel approaches to Science, Technology, Engineering and Math (STEM) education at the undergraduate level. ABSL combines traditional service learning with novel undergraduate research on a community problem. For the service-learning portion of the class, students spend a set number of hours throughout the semester in a specific community environment so that they learn about and understand the community problem. In class, the students conduct novel research, using the scientific method, on various parts of the community problem and investigate solutions to the problem.

Purdue University
Various CT Assessments

- **CAT**
  - Portfolios, Rubrics, & other Tests
    - (CLA, CCTST, CAAP CT module)

- **IDEA Teaching Evaluations**
  - NSSE/CSSE & other surveys

- **Alumni & Employer surveys**

**Outcomes**

- **Student Performance**
- **Student Perceptions**
- **Alumni/Employer Perceptions**
Using Multiple Measures

- Surveys
- Portfolios with Rubrics
- Other Performance Assessments
- Assessment of Important Course Assignments
Assessment Uses of CAT

Informal Learning Experiences

Classroom Learning Experiences

Program Outcomes

Value Added Enter vs. Exit

College Outcomes

Tracking Outcomes Over Time

Norm Referenced
### Student Information

<table>
<thead>
<tr>
<th>Student ID Number</th>
<th>What is your Age?</th>
<th>Local Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. What is your gender? Select One.
   - [ ] Male
   - [ ] Female

Note: Please answer BOTH Questions 2 and 3.

   - [ ] Yes
   - [ ] No

3. What is your race? Select one or more categories to indicate your race (from U.S. Census Categories).
   - [ ] White
   - [ ] Black or African American
   - [ ] Native Hawaiian or Other Pacific Islander
   - [ ] American Indian or Alaska Native
   - [ ] Other race

4. Do you consider English your primary language? Select One.
   - [ ] Yes
   - [ ] No

5. Rate your proficiency with the English Language. Select level of proficiency.
   - [ ] Excellent
   - [ ] Very Good
   - [ ] Good
   - [ ] Fair
   - [ ] Poor

6. What is your class standing?
   - [ ] Freshman
   - [ ] Sophomore
   - [ ] Junior
   - [ ] Senior
   - [ ] Undergraduate
   - [ ] Graduate

7. Undergraduate or Graduate?
CAT Overview: Descriptive Statistics for CAT Total Score
Sample Institution: Date 2010

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT Total Score</td>
<td>50</td>
<td>11.00</td>
<td>36.00</td>
<td>24.32</td>
<td>5.52</td>
</tr>
</tbody>
</table>

Average Total Points Attained

CAT Demographics: Descriptive Statistics for Sample

<table>
<thead>
<tr>
<th>Gender</th>
<th>Freq.</th>
<th>Freq. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>18</td>
<td>48.9%</td>
</tr>
<tr>
<td>Female</td>
<td>32</td>
<td>51.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class Standing</th>
<th>Freq.</th>
<th>Freq. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>36</td>
<td>36.7%</td>
</tr>
<tr>
<td>Sophomore</td>
<td>31</td>
<td>31.9%</td>
</tr>
<tr>
<td>Junior</td>
<td>18</td>
<td>18.3%</td>
</tr>
<tr>
<td>Senior</td>
<td>15</td>
<td>15.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>Freq.</th>
<th>Freq. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>72</td>
<td>72.7%</td>
</tr>
<tr>
<td>Graduate</td>
<td>28</td>
<td>28.3%</td>
</tr>
<tr>
<td>25-26 years</td>
<td>1</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Freq.</th>
<th>Freq. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent English Proficiency</td>
<td>71</td>
<td>72.2%</td>
</tr>
<tr>
<td>Very Good</td>
<td>17</td>
<td>17.5%</td>
</tr>
<tr>
<td>Good</td>
<td>5</td>
<td>5.3%</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
<td>0.0%</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

**The cumulative percent may exceed 100% as students are allowed to select more than one category.**

Center for Assessment & Improvement of Learning © 2007, 2010
## CAT Means Comparison Report
### Sample Institution: Date 2010 (N=25)

<table>
<thead>
<tr>
<th>Evaluate</th>
<th>Problem Solving</th>
<th>Creative Thinking</th>
<th>Effective Comm.</th>
<th>Skill Assessed by CAT Question</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Q1</td>
<td>Summarize the pattern of results in a graph without making inappropriate inferences.</td>
<td>Pre Mean</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.48</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td>Q2</td>
<td>Evaluate how strongly correlational-type data supports a hypothesis.</td>
<td>.39</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td></td>
<td>Q3</td>
<td>Provide alternative explanations for a pattern of results that has many possible causes.</td>
<td>.79</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Q4</td>
<td>Identify additional information needed to evaluate a hypothesis.</td>
<td>.81</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>X</td>
<td>Q5</td>
<td>Evaluate whether spurious information strongly supports a hypothesis.</td>
<td>.58</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Q6</td>
<td>Provide alternative explanations for spurious associations.</td>
<td>.91</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Q7</td>
<td>Identify additional information needed to evaluate a hypothesis.</td>
<td>.58</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td>Q8</td>
<td>Determine whether an invited inference is supported by specific information.</td>
<td>.45</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Q9</td>
<td>Provide relevant alternative interpretations for a specific set of results.</td>
<td>.70</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td></td>
<td>Q10</td>
<td>Separate relevant from irrelevant information when solving a real-world problem.</td>
<td>3.39</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Q11</td>
<td>Use and apply relevant information to evaluate a problem.</td>
<td>1.15</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td></td>
<td>Q12</td>
<td>Use basic mathematical skills to help solve a real-world problem.</td>
<td>.79</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td></td>
<td>Q13</td>
<td>Identify suitable solutions for a real-world problem using relevant information.</td>
<td>.88</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Q14</td>
<td>Identify and explain the best solution for a real-world problem using relevant information.</td>
<td>1.30</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Q15</td>
<td>Explain how changes in a real-world problem situation might affect the solution.</td>
<td>.30</td>
</tr>
</tbody>
</table>

**CAT Total Score**

<table>
<thead>
<tr>
<th>Pre Mean</th>
<th>Post Mean</th>
<th>Probability of difference</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.51</td>
<td>16.33</td>
<td>***</td>
<td>+.55</td>
</tr>
</tbody>
</table>

* p<.05  **p<.01  ***p<.001 (2 -tailed)

b. Mean difference divided by pooled group standard deviation.

(0.1 - 0.3 = small effect; 0.3 - 0.5 = moderate effect; >0.5 = large effect)

The map of skills covered by each question above is a suggested theoretical guide for interpreting results.
National Dissemination Model

Institution
8 – 14 Faculty Involved in Scoring

CAT Regional Training

2 - 3 Representatives
www.CriticalThinkingTest.org

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