

From Local Assessment to Changing Classroom Practices Nationally and Internationally:

Improving Students' Critical Thinking Using the CAT (Critical thinking Assessment Test)

Ada Haynes, Ph.D.

Tennessee Tech University

Elizabeth Lisic, Ph.D.

Tennessee Tech University

Denise Drane, Ph.D.

Northwestern University



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Importance of Critical Thinking

99.6% agree critical thinking skills are "very important" or "essential"

40% feel they lack the resources and training needed to effectively teach critical thinking

Viral Nature of Misinformation

Confirmation
Bias

Fallacy



Search
≠
Research

The Changing Nature of Education



**Remembering
Information**

**Finding Relevant
Information**

**Understanding &
Evaluating Information**

**Using Information
Effectively**

What is Critical Thinking?

Classic Emphasis

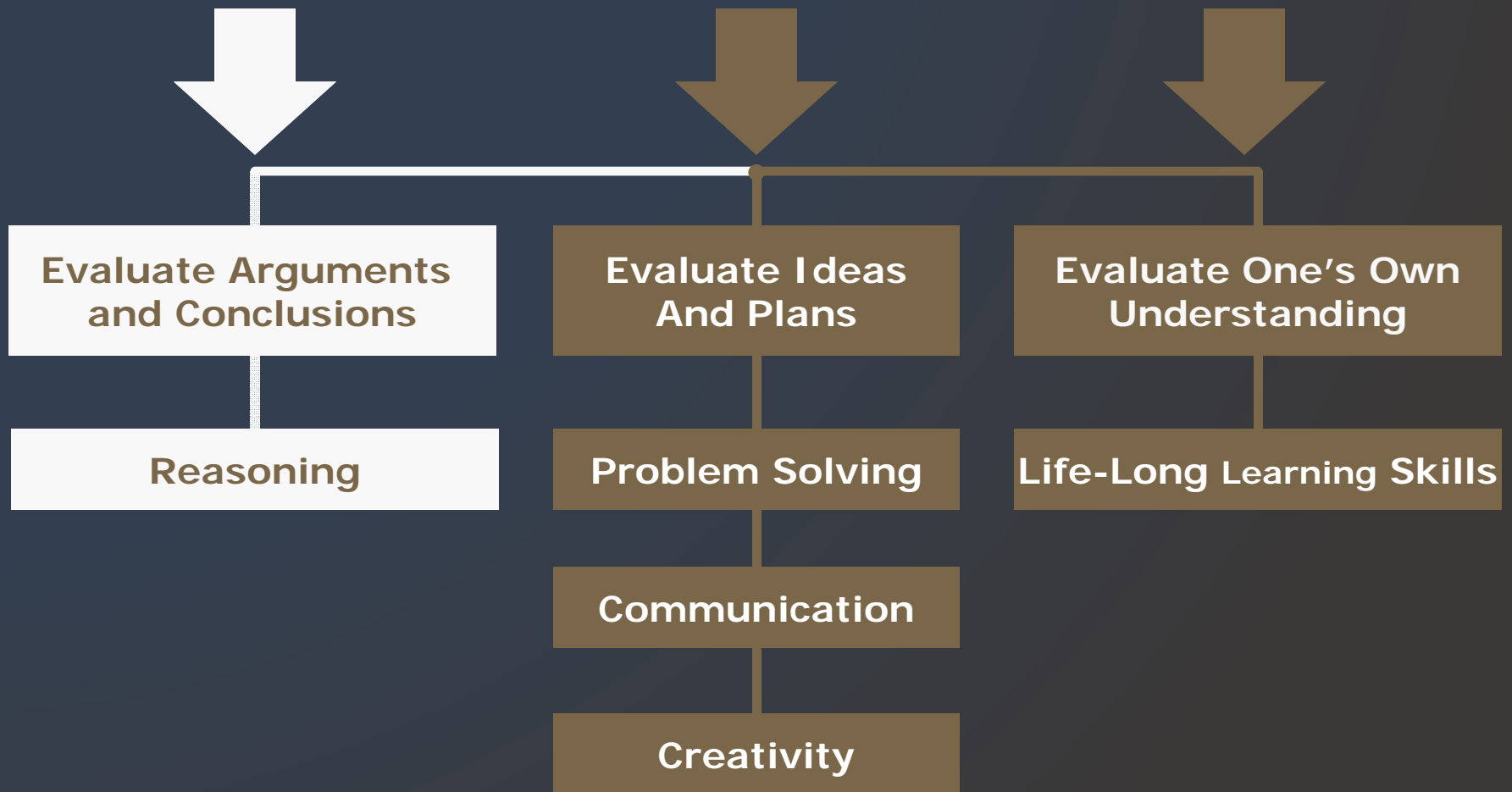
Evaluate Arguments and Conclusions

Reasoning

What is Critical Thinking?

Classical Emphasis

Expanded Contemporary Emphasis



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



Collaborate With Other
Institutions To Refine CAT
2004 - 2007



Develop Training Methods for
National Dissemination & Collect Norms
2007 - 2010



Expand National Dissemination
& Support Assessment in NSF Projects
2010 - 2016

Over 250 US Institutions



+ Australia, Canada, Japan, Palestine, and
Qatar Collaborating

Skills Evaluated by CAT Instrument

Evaluating
Information

Creative
Thinking

Learning &
Problem
Solving

Communication

Informed Consent

The purpose of this study is to understand the relevance of critical thinking skills foundational to the CAT across cultures (individualistic and collectivist).

By answering the questions on this survey you are agreeing to participate in our study.

CAT Features

One hour exam

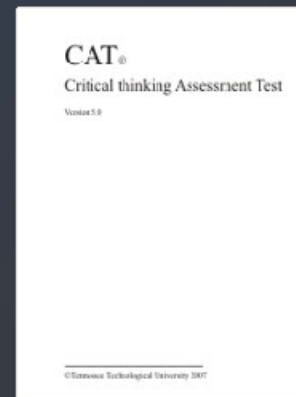
Mostly short answer essay

Faculty scored in workshops

Detailed scoring guide

Reliable

Valid



Test Booklet



Additional Information Packets

Sample Disclosed Question

A scientist working at a government agency believes that an ingredient commonly used in bread causes criminal behavior. To support the hypothesis the scientist notes the following evidence.

- 99.9% of the people who committed crimes consumed bread prior to committing crimes.
- Crimes 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 from the data besides the scientist's hypothesis? If so, describe.

What kind of additional information or evidence would help support the scientist's hypothesis?

2. Other explanations for evidence offered by scientist? (**Three points maximum**)

Step 1: Are other explanations indicated?

Yes (or implied by any alternative)	No
Add 1 pt. <i>Ex: Yes, there are other explanations.</i> <i>Ex: The data are faulty.</i> Go to Step 2	0 pts. <i>Ex: I don't think so.</i> (Stop here)



Step 2: Evaluate relevance of the explanations (2 additional pts. possible)

<p>Add 1 pt.</p> <p>If the explanation points out the spurious connection between bread consumption and criminal behavior.</p> <p><i>Ex: There is not necessarily a strong association because bread is a commonly consumed food in many households. That would be like saying that soap may be the cause because it was found in the homes of all of those who committed crimes.</i></p>
<p>Add 1 pt.</p> <p>If the answer points out that those areas where bread is not consumed may not have human residents or an infrastructure to easily report and document criminal behavior.</p> <p><i>Ex: Areas where bread is not consumed may have a very small population or no human residents.</i></p> <p><i>Ex: Crime may not be reported and documented the same way in cultures that do not consume bread.</i></p>

Discussion Points

Did students respond the way you anticipated?

What can we learn about students from these responses?

How can we help students improve these skills?

24 Question Survey

Amount of
experience
scoring
the CAT

Obstacles
related to
change in
courses

Changes to
teaching and
assessment
practices

Motivational
factors and
available
incentives

**Amount of Experience
Scoring the CAT
Instrument**



**Change in
Teaching
Strategies**

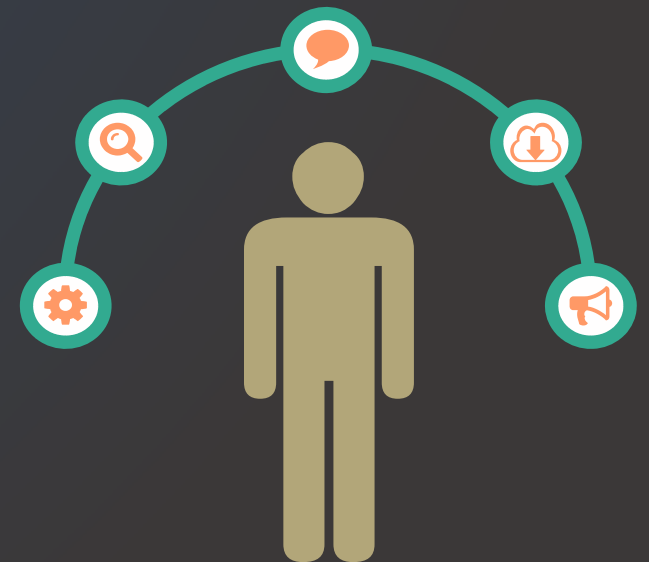
**Change in
Assessment
Strategies**

participating in even one CAT Scoring workshop led to significant change in teaching strategies

Experiential Learning

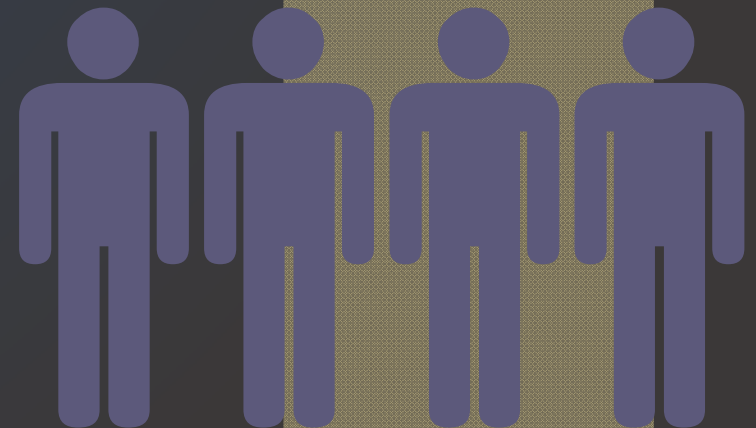
Application

Successful Training Outcomes



greater level of exposure is required to make changes in assessment practices

- Overcome deficits in training related to assessment
- Provide a model for the development of course based assessment



Model for Change

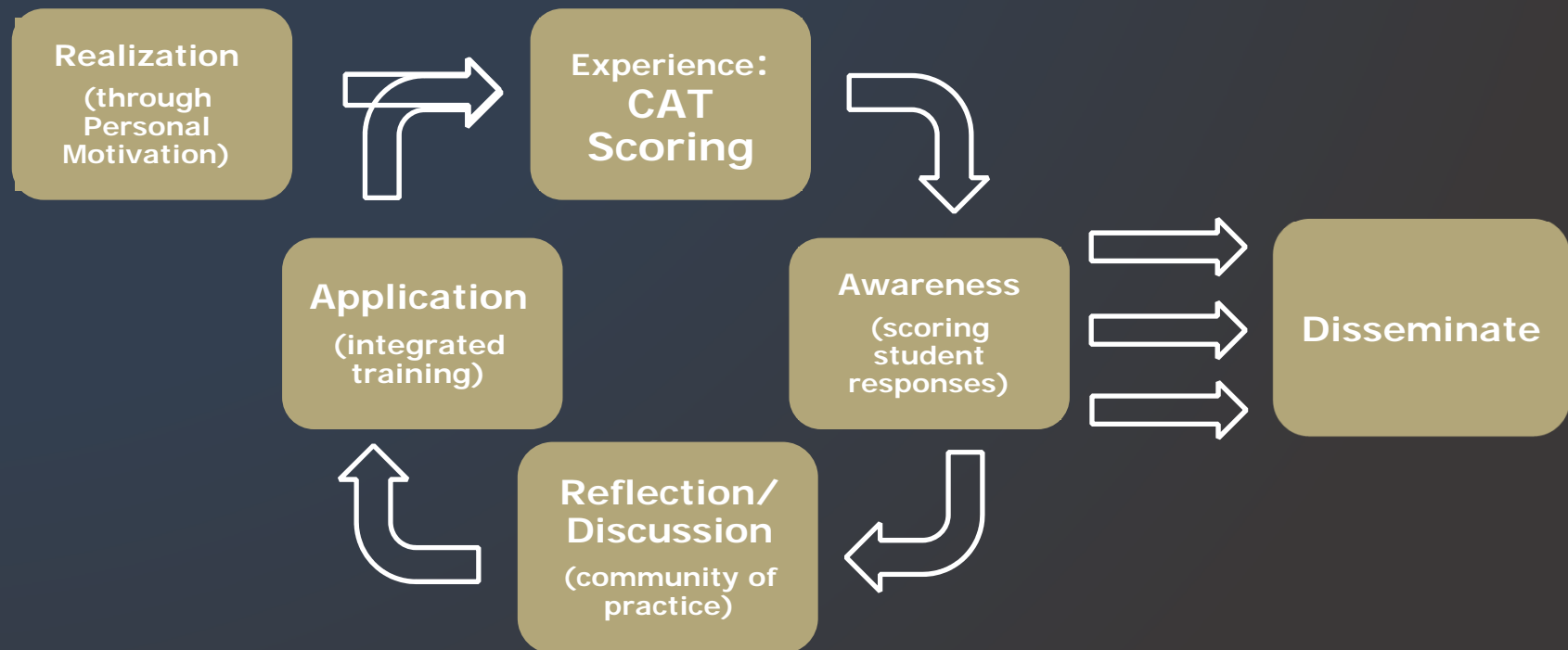
Opportunities
for
training/faculty
development
focused on
high impact
practices

Obstacle—
Lack of
personal
motivation

Being part of
a faculty
community
focused on
improving
critical
thinking

Experienced
scoring
responses
from your
own students

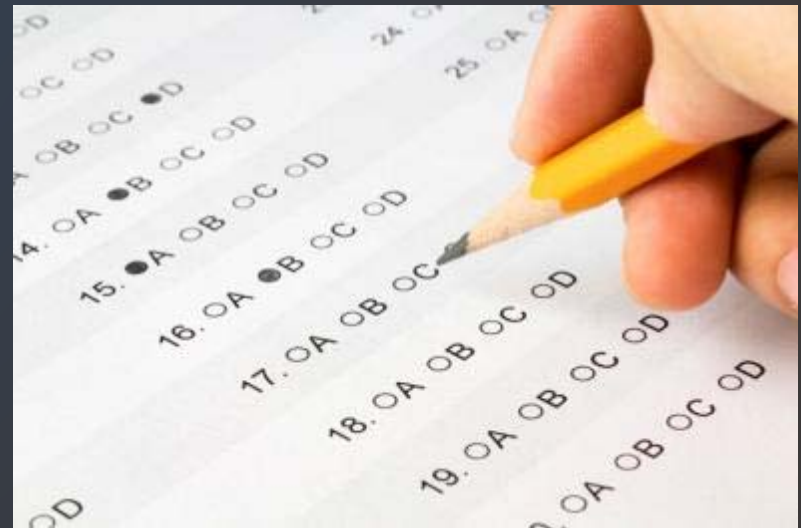
Experiential Development Model of CAT Scoring



Understanding the Disconnect



Teaching Critical Thinking



Assessing Factual Knowledge

Validating Evidence Based Practices

PRE

CAT Apps

Other Innovative Pedagogy

POST



Scaling a Critical Thinking Initiative Across Disciplines

Denise Drane PhD

Searle Center for Advancing Learning and Teaching

Northwestern University



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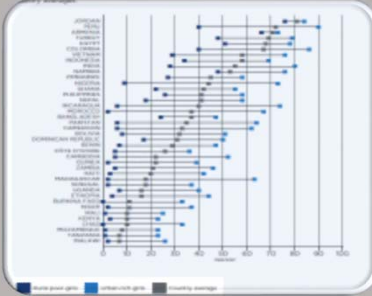
Research Hypotheses

1. Critical thinking can be leveraged to deeply engage faculty.

2. Data on students' critical thinking will motivate faculty to change their teaching

3. Changes in faculty approaches to teaching will lead to greater student gains in critical thinking

Research Program Goals



To present faculty with assessment data on student gains in critical thinking



To inspire faculty to make changes to their teaching



To see if changes in teaching result in greater gains in critical thinking in students



Study Participants

11 faculty City Colleges of Chicago
&
9 faculty Northwestern University

Anatomy

Astronomy

Biology

Calculus

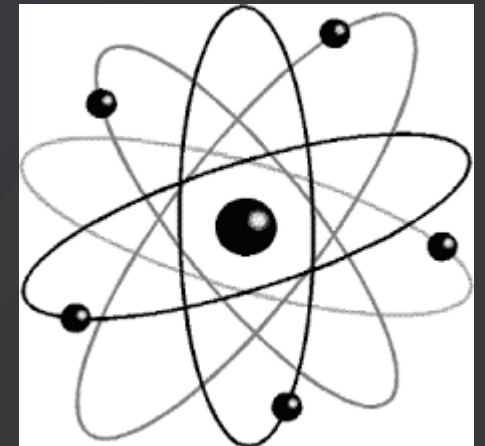
Chemistry

Chemical Engineering

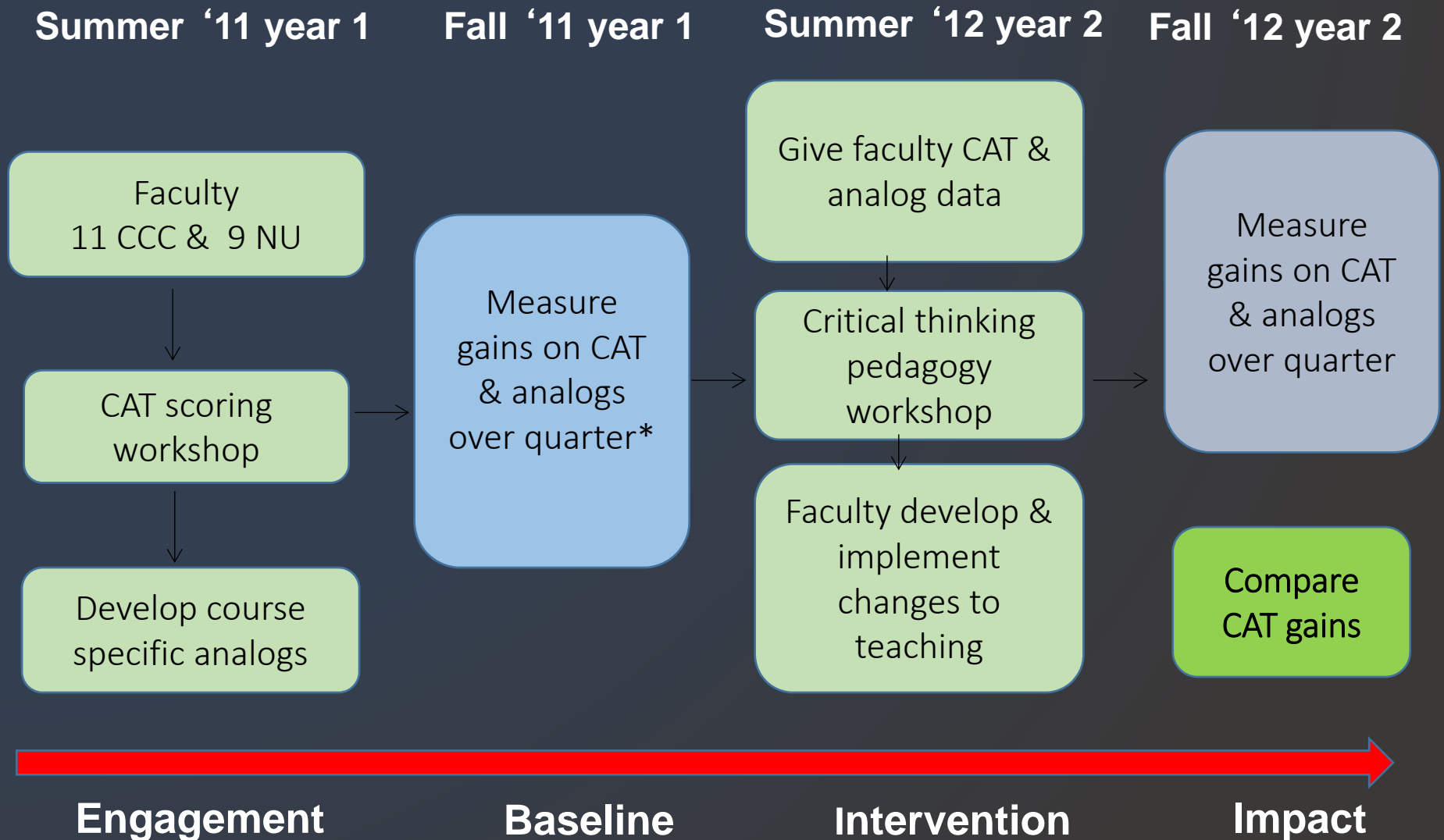
Electrical Engineering

Linguistics

Physics



Critical Thinking Initiative in STEM: Study Design



*241 students completed both pre and post CAT

What does critical thinking
look like across the
disciplines?

Community College: Physical Science

A friend of yours is trying to grow a tomato plant in her apartment. She has it in a pot on a table by a window, but it is not growing quickly. She notices that some flowers that she keeps on her balcony are growing very quickly, and she wonders if it is because she uses fertilizer on the flowers, but not on the tomato.

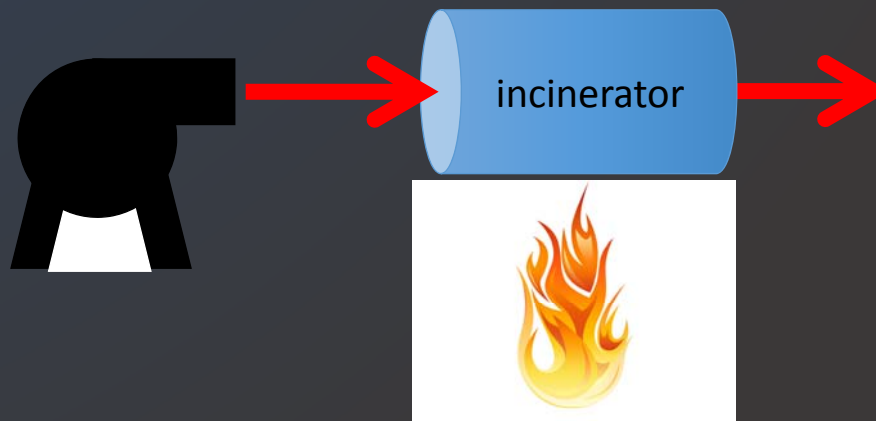
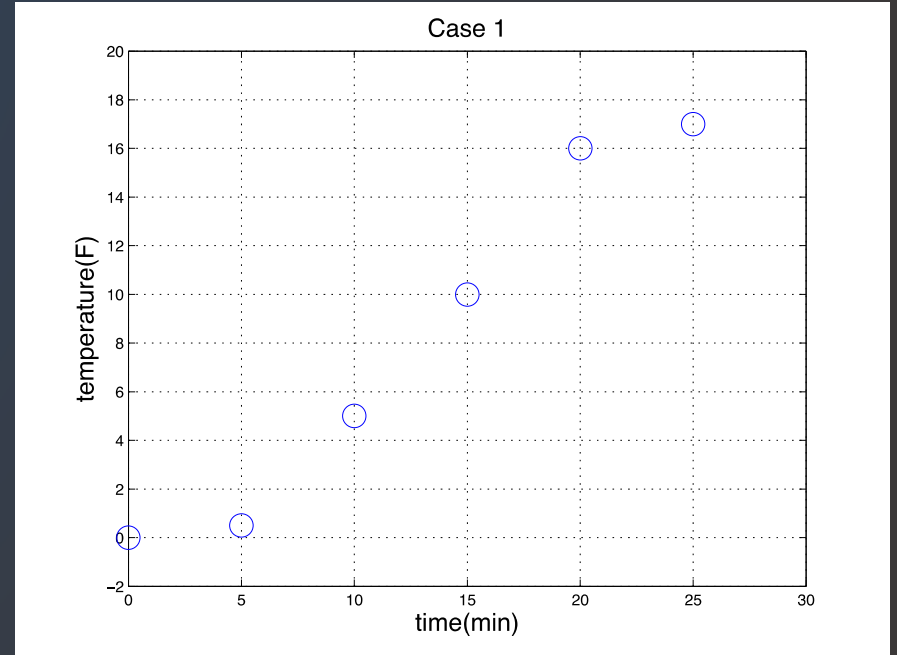
- Provide three alternative explanations for the difference in growth rate between the tomato plant and the flowers, other than fertilizer usage.
- Describe an experiment that would allow her to determine if it was in fact the lack of fertilizer that was responsible for the low growth rate of the tomato plant.

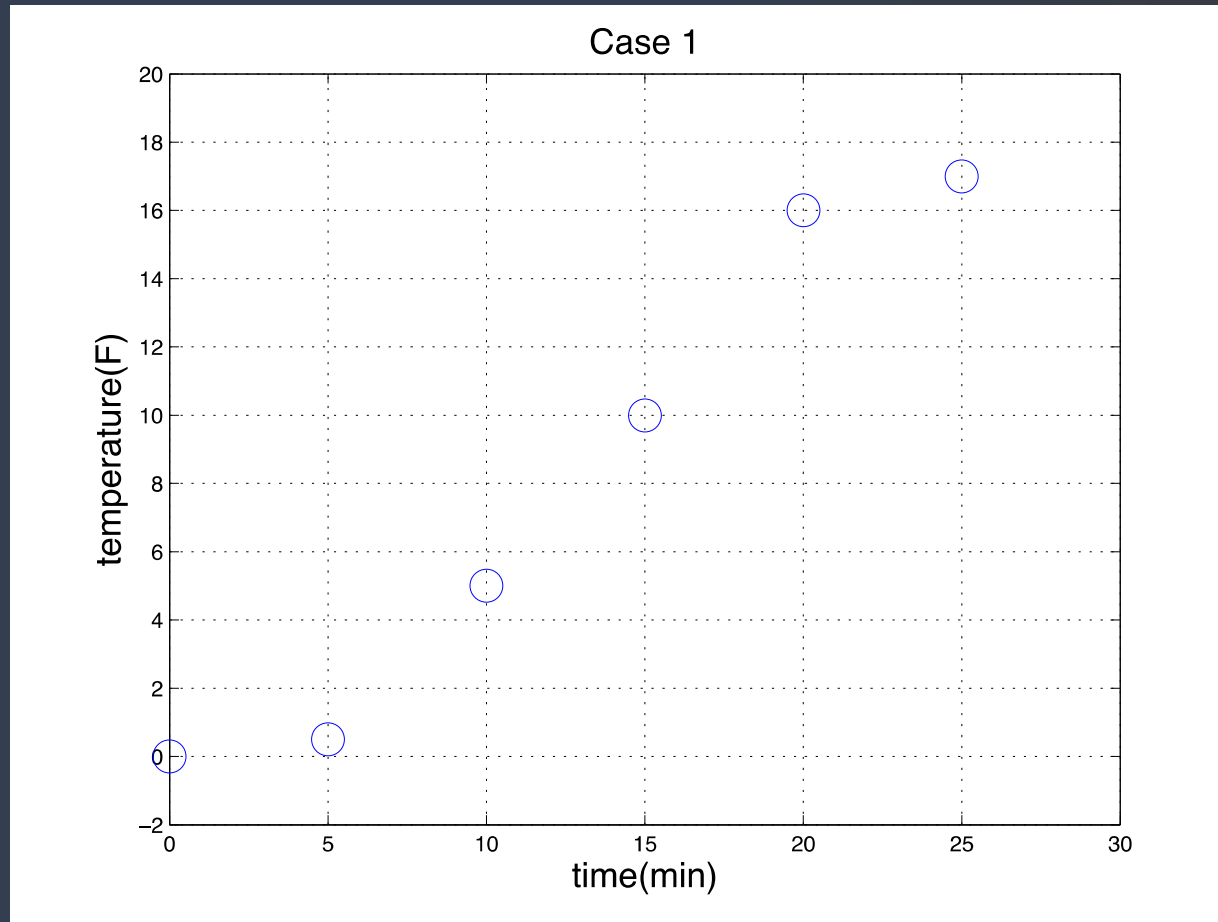
Identify alternative interpretations for data or observations.

Identify new information that might support or contradict a hypothesis.

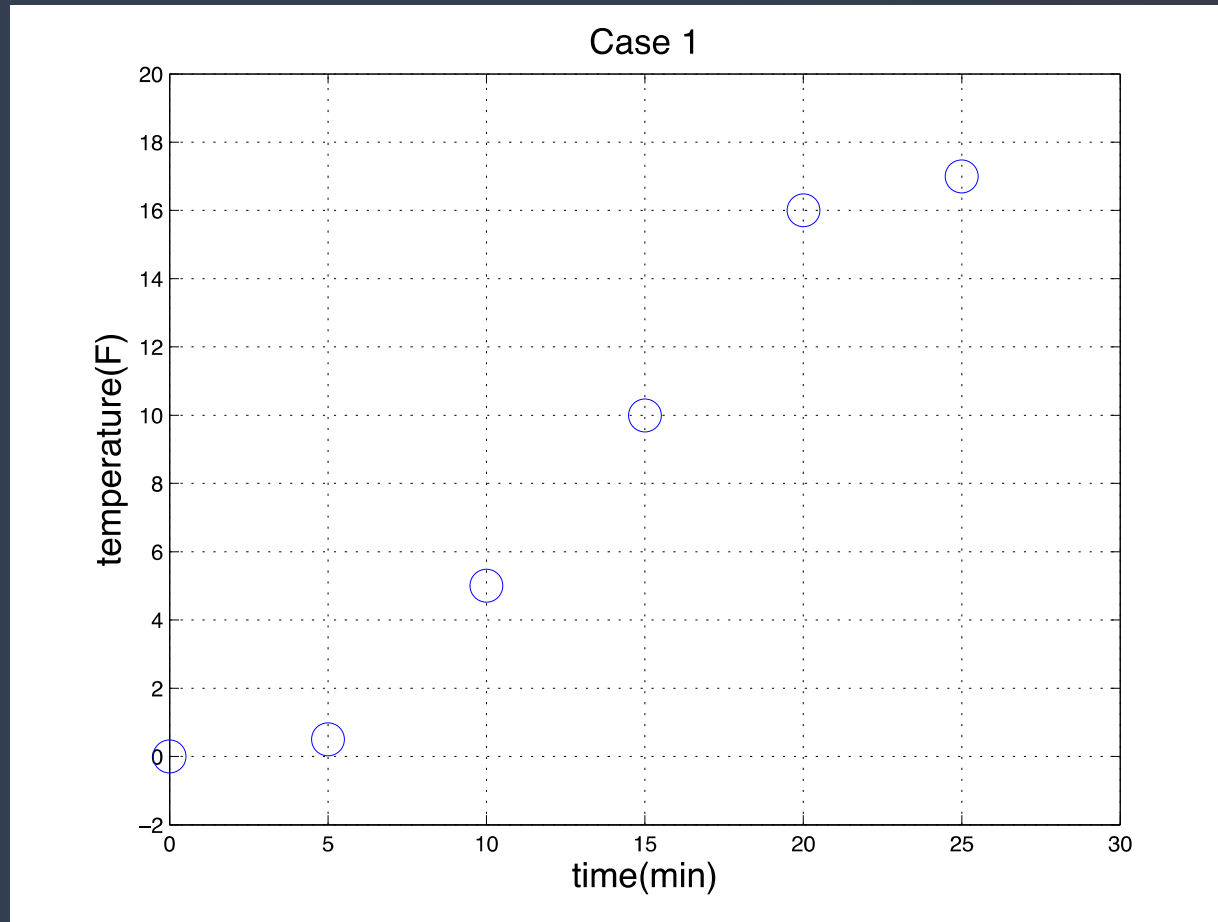
Dynamics and Control of Biological and Chemical Systems

- Start with a set of “actual” experimental data

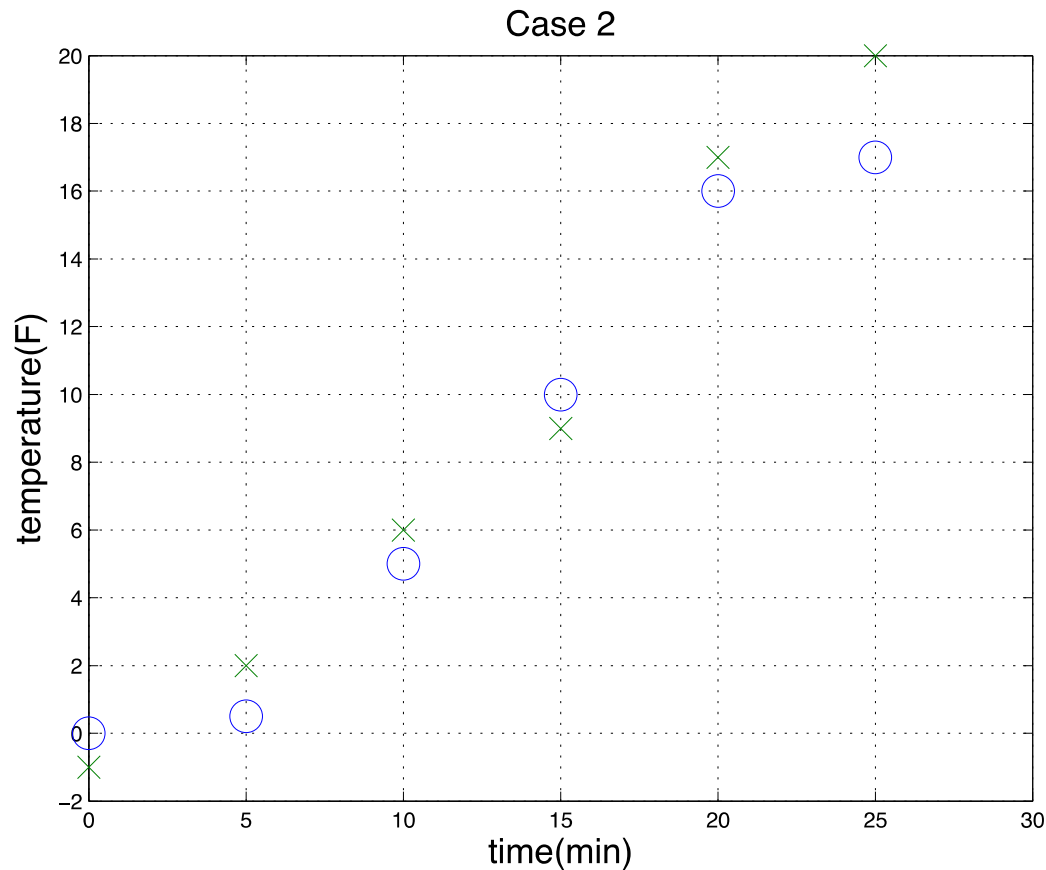




1. Summarize/interpret these data. What conclusions can be drawn?
2. How strongly do these data support the hypothesis that the system exhibits FODT behavior?



3. Propose an alternative hypothesis that your team finds most compelling, and then propose additional experiments that could be conducted to evaluate your hypothesis. Explain why these experiments would let you evaluate which of these two hypotheses is most supported.



4. Now you repeat the experiment and measure the new data (X) shown above. To what extent do these new data support the original hypothesis and each of the alternatives proposed?

College Chemical & Environmental Engineering

You are an engineer at Dow Chemical looking to make a new product by one of two processes A and B described in patents and summarized below. Both processes use the same reactants, have the same products, and generate the same overall yields.

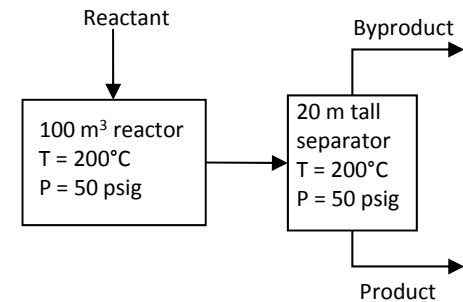
You hire an experienced consultant. Dow seeks the process with lowest total costs to build and operate.

- **Consultant recommends process A** for a company that wishes to make 10,000 tons/yr of product.

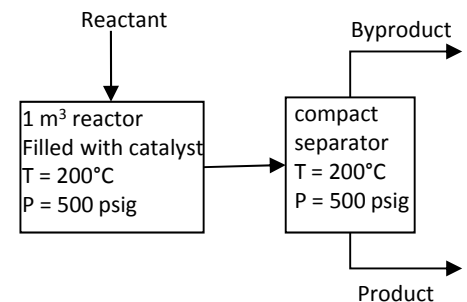
Does this mean that process A is lowest cost to construct?

- **Circle the most relevant pieces of information.**
- List at least **three other reasons** why consultant would have recommended this process.
- What **other info** could the consultant have used?

Process A: Patent 1,234,567, year 1978



Process B: Patent 4,567,890, year 2010



**Additional info:
(omitted here)**

Thanks to faculty
JN for this slide

Results: Hypothesis 1

Critical thinking can be leveraged to deeply engage faculty.

All faculty developed activities to enhance critical thinking

All but one developed questions to assess critical thinking.

Results: Hypothesis 2

Data on students' critical thinking will motivate faculty to change their teaching

Approaches to Teaching Inventory

(Trigwell, Prosser & Ginns, 2005)

- No group level changes
- 8/16 small to moderate increases on conceptual change
- 8/16 small to moderate decreases on information transmission

Results: Hypothesis 3 City Colleges of Chicago

Changes in faculty approaches to teaching will lead to greater student gains in critical thinking

Course Specific (Analog) Assessments

- Gains larger in Intervention Semester
- 6/8 classes
- Effect sizes 0.37 to 10.92



CAT Test

- No difference in gains between baseline and intervention semesters



Results: Hypothesis 3 University

Changes in faculty approaches to teaching will lead to greater student gains in critical thinking

Course Specific (Analog) Assessments

- Gains larger in intervention semester
- 1/2 classes
- Effect sizes 0.19



CAT Test

Gains larger in intervention quarter

3/7 classes larger gains in total score

4/7 classes larger gains on target questions



Activity to Promote Critical
Thinking
in
Solid State Electronic Devices

#1) For the following basis vectors, what is the unit cell volume?

A. a^3

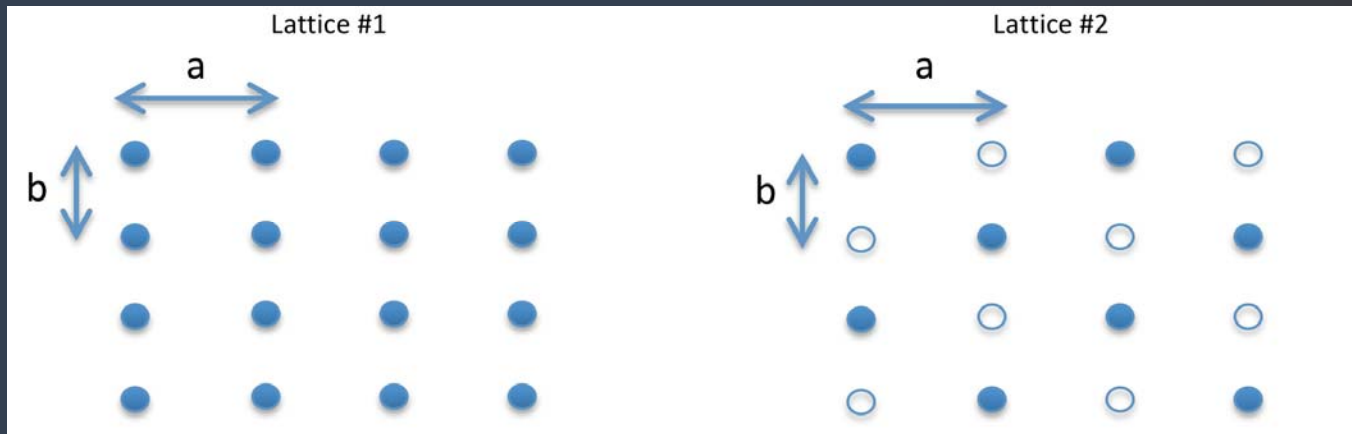
B. $a^3/2$

C. $2a^3$

D. $a^3/4$

$$\mathbf{a} = a\hat{\mathbf{x}} \quad \mathbf{b} = \frac{a}{2}\hat{\mathbf{x}} + \frac{a}{2}\hat{\mathbf{y}} \quad \mathbf{c} = a\hat{\mathbf{z}}$$

Quiz Team Questions,
Round 1-A



#2) Select all point group symmetries (if any) that the left lattice has and the right does not have:

- A. reflection through a point about vertical axis
- B. reflection through a point about horizontal axis
- C. rotation through a point by 90 degrees
- D. translation to the right by a

#5) Crystal systems are defined by point group symmetries alone, whereas Bravais lattices are additionally defined by translational symmetries.

- T. True
- I. Insufficient Information
- F. False

#1) For the following

- A. a^3
- B. $a^3/2$
- C. $2a^3$
- D. $a^3/4$



#2) Select all point group symmetries (if any) that the grid does not have:

- A. reflection through a point about vertical axis
- B. reflection through a point about horizontal axis
- C. rotation through a point by 90 degrees
- D. translation to the right by a

#5) Crystal systems are defined by point group symmetries. Cubic lattices are additionally defined by translation.

- T. True
- I. Insufficient Information
- F. False

NAMES: _____ Jane Student _____ A
_____ Bobby Undergrad _____ I
_____ David Grad _____ I

MULTIPLE CHOICE

True/Insuff./False

#5)

T



F

#6)

T

I

F

#7)

T

I

F

#8)

T

I

F

#2)

A

B



D

#3)

A

B

C

D

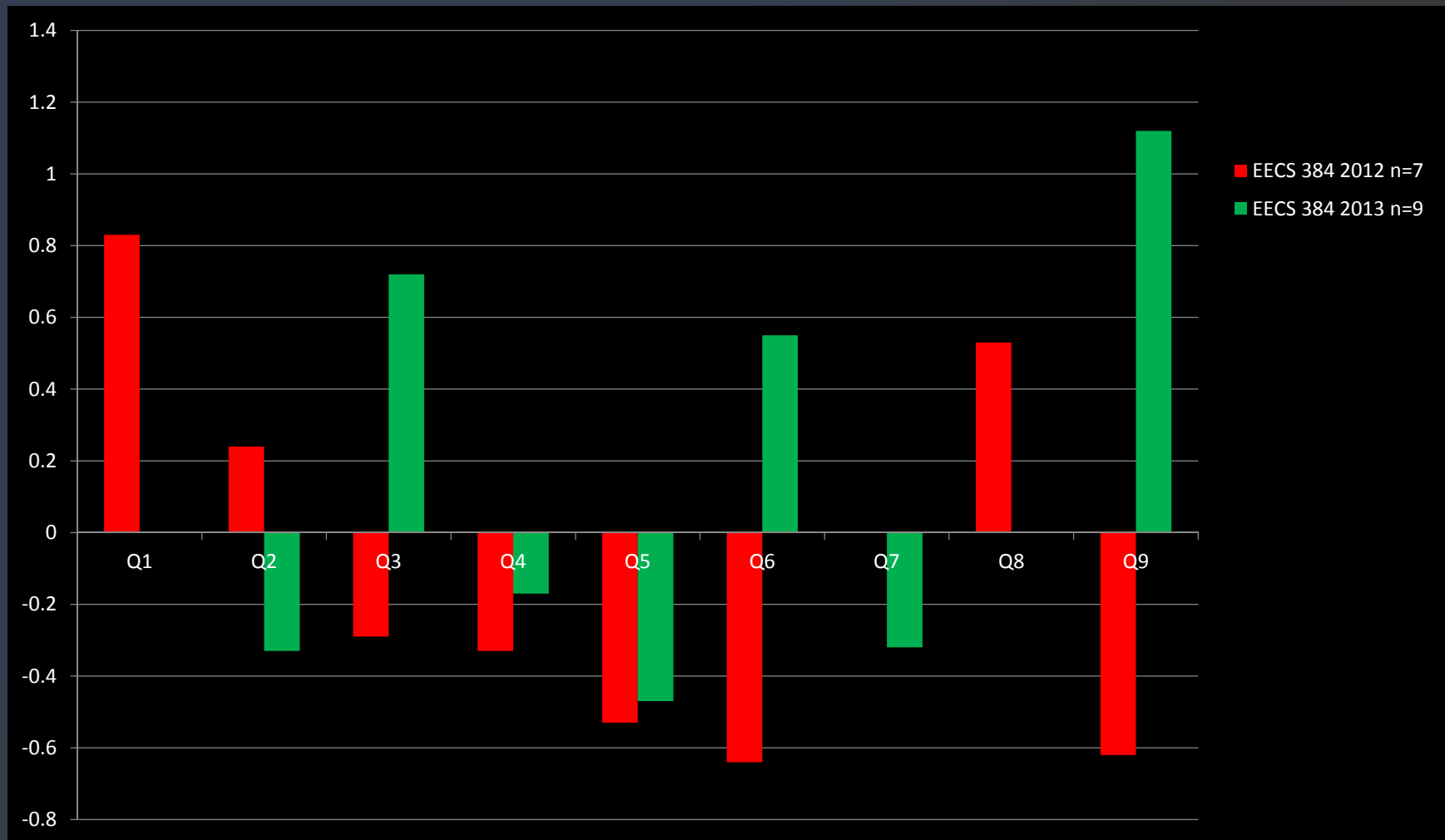
C

D

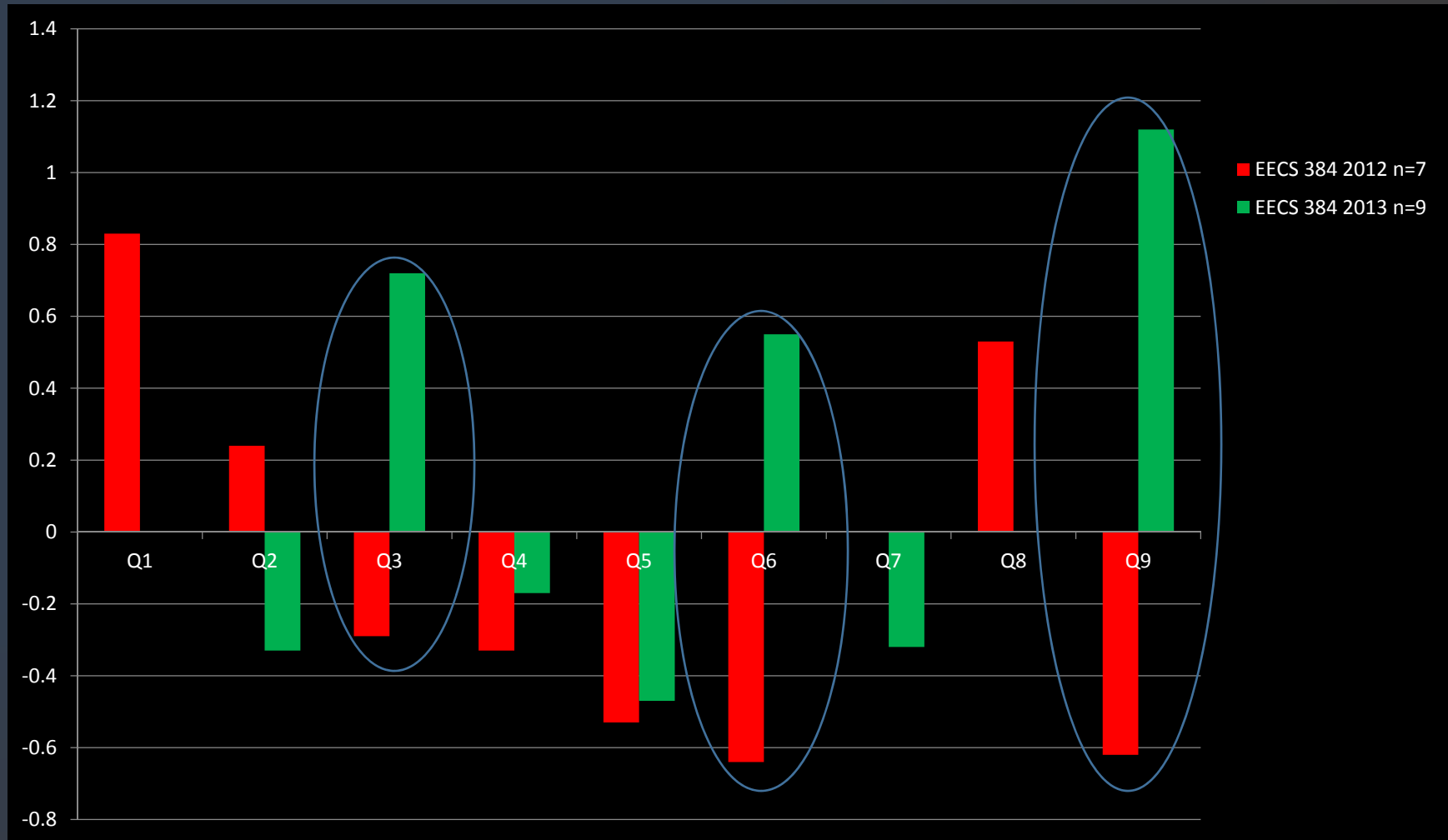
Case Study: Learning Outcomes in terms of CAT Skill Areas and CAT Question

Learning Outcomes	CAT Skill Areas			
	Evaluate/ interpret info	Problem Solving	Creative Thinking	Effective Communication
Dynamic group thinking skills	2, 5	4,7	4,7	2, 4, 7
Develop awareness of multiple perspectives				
Present, defend, evaluate critical responses			9	9
Critical skills with different team partners			3,6	3,6

Results: Student Gains in Critical Thinking



Results: Student Gains in Critical Thinking



The Value of a Framework

“The materials helped me verbalize what we’re doing. We are doing this and making it clear to students what they are doing, they are critical thinkers.”

“Being able to review the results of the test to get at the root of what is and is not good critical thinking. The topic was subconscious to me, and this brought it to the surface.”

“How to look at learning outcomes from a different point of view. I was forced to think about what critical thinking is and define it and how to measure it.”

“It was really helpful to formalize it and validate what we are doing.....I never really thought about what I was doing. We grew up doing it, but now we have words for why we are doing it.”

The value of a Community of Practice

“I liked hearing other people’s ideas, especially. Immediate feedback and great ideas from the other teachers. That was the primary benefit. That was the best part”

“Seeing the diversity of ways people were going about attacking critical thinking and all accomplishing it. People got validated – I got validated. We’re all on track!”



The value of the Experience

“It forced me to develop my craft.”

“It forced me to look at what I teach differently”.

“Definitely. It allowed me to critically evaluate my teaching. It was very, very good.”

Translating the CAT across Cultures

Sami Basha PhD,
Palestine Ahliya University College
Bethlehem, West Bank



Preliminary Validation Study

- Response of students to the CAT
- Faculty Perceptions of the CAT skills



Student Response: Study 1

- Students from 2 large universities in the West Bank
- English speakers (n=30) full CAT test
- Problematic (n=2)
- “As the questions are related to cases in foreign country, it is difficult to think for possible answers.”
- “Because it was my very first time reading about purification”

A High Level of Interest

- Rated 1-7 scale (very interesting-not very interesting at all)
- 66% rated 1 or 2
- Request for instruction in critical thinking
- Gained from doing test

Test directions confusing n=10

- “When I know that it is a critical thinking assessment, I started criticizing everything and said no to almost every question. May be I should not have been told to give more accurate information.”
- “It is complicated. Too many answers needed to be written with explanations”
- “It depends on my analytical competencies”.

Study 2: Faculty Response

- Universities across West Bank & Gaza
- 75% full-time
- 74% male
- Disciplines
 - 14% medical school
 - 26% humanities
 - 13% business
 - 32% STEM
 - 15% other

Response by Faculty

Skill	Agree
Summarize a pattern of information without making inappropriate inferences	52.7%
Evaluate how strongly information supports a hypothesis or interpretation	73.2%
Provide alternative explanations for observations	68.7%
Identify additional information needed to evaluate a hypothesis or particular explanation of an observation.	61.6%
Evaluate whether spurious relationships strongly support a claim	41.9%

Thank You

www.CriticalThinkingTest.org



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.