Developing Skills for the 21st Century: Assessing and Improving Critical Thinking

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WASC 2012 Annual Meeting

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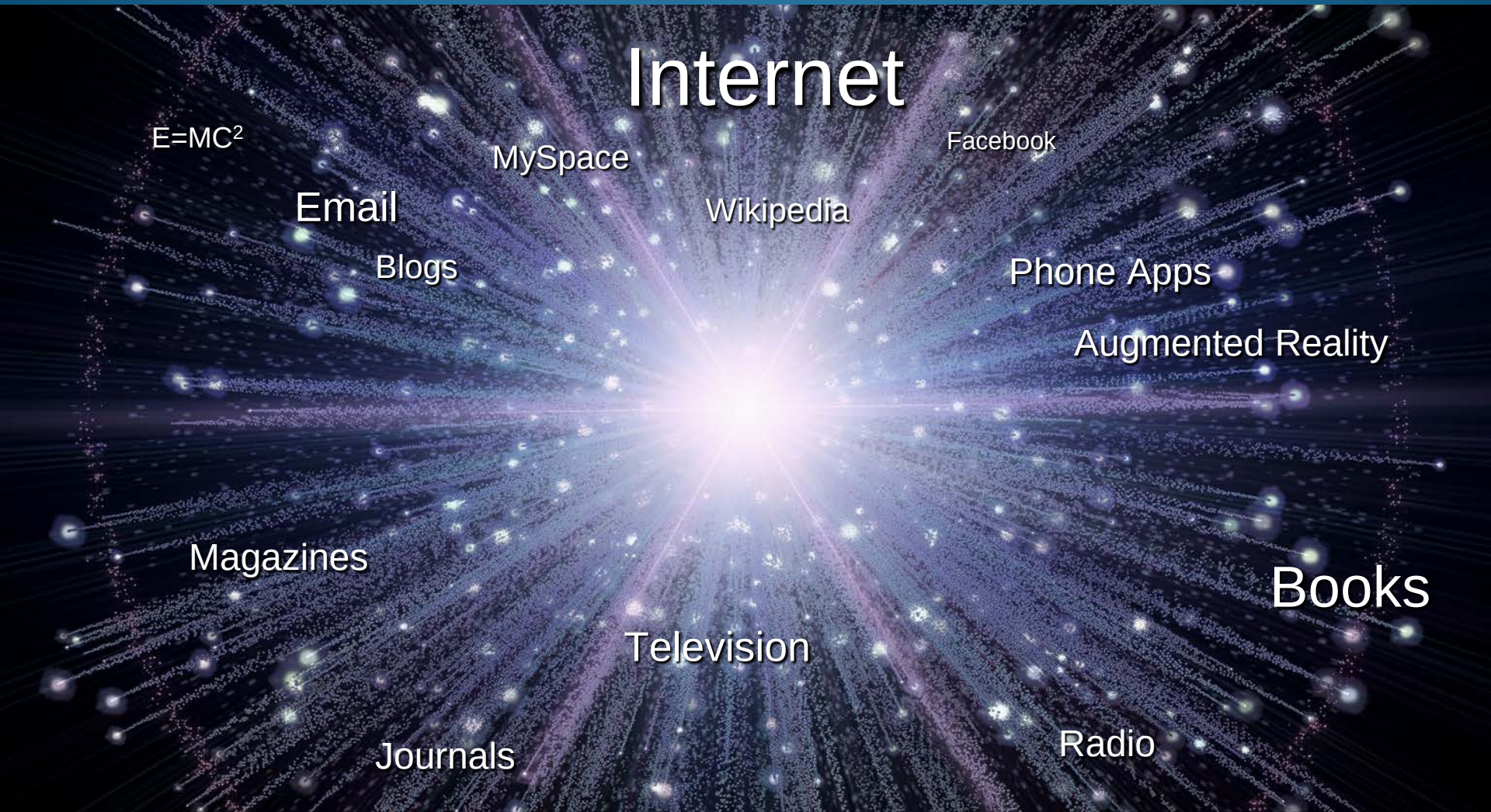
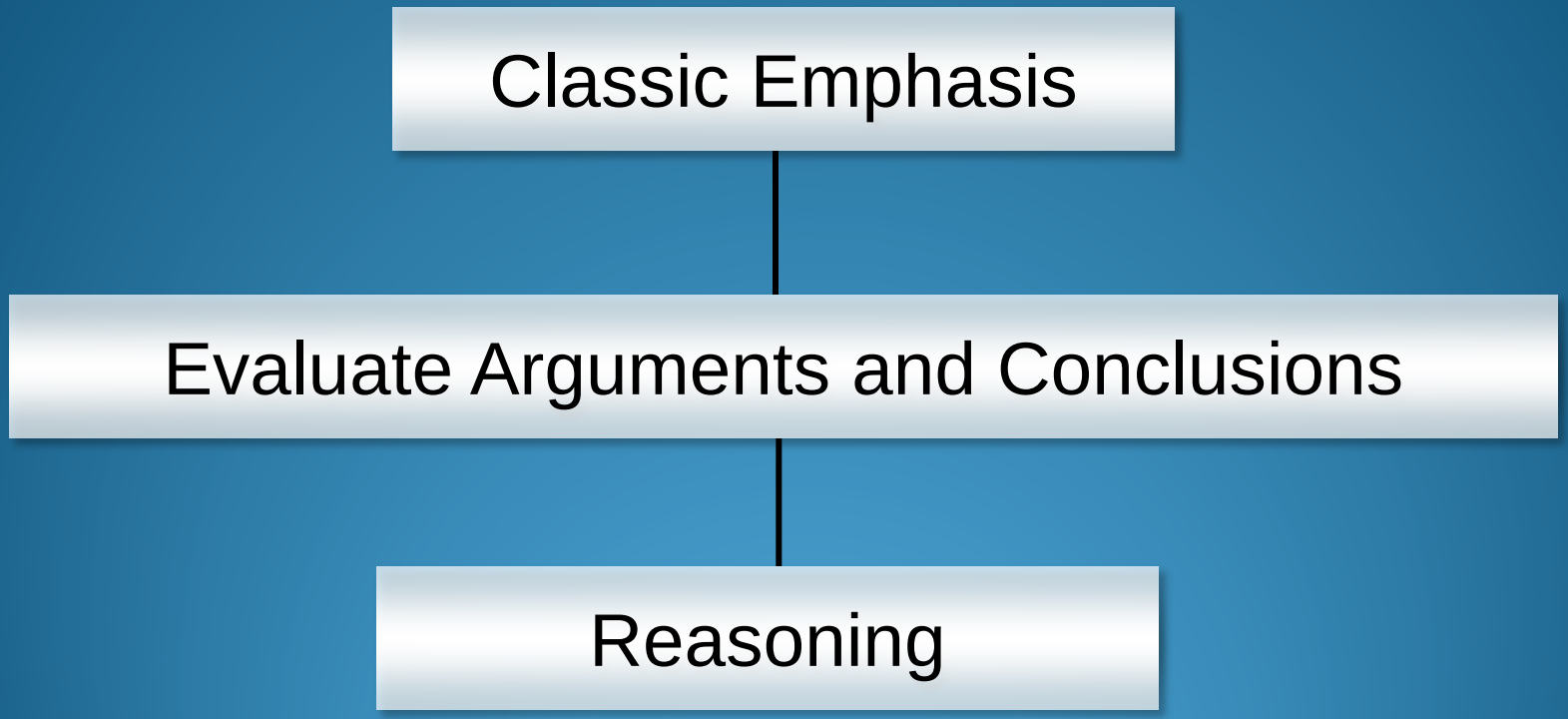
Importance of Critical Thinking

Explosion of Information



What is Critical Thinking?



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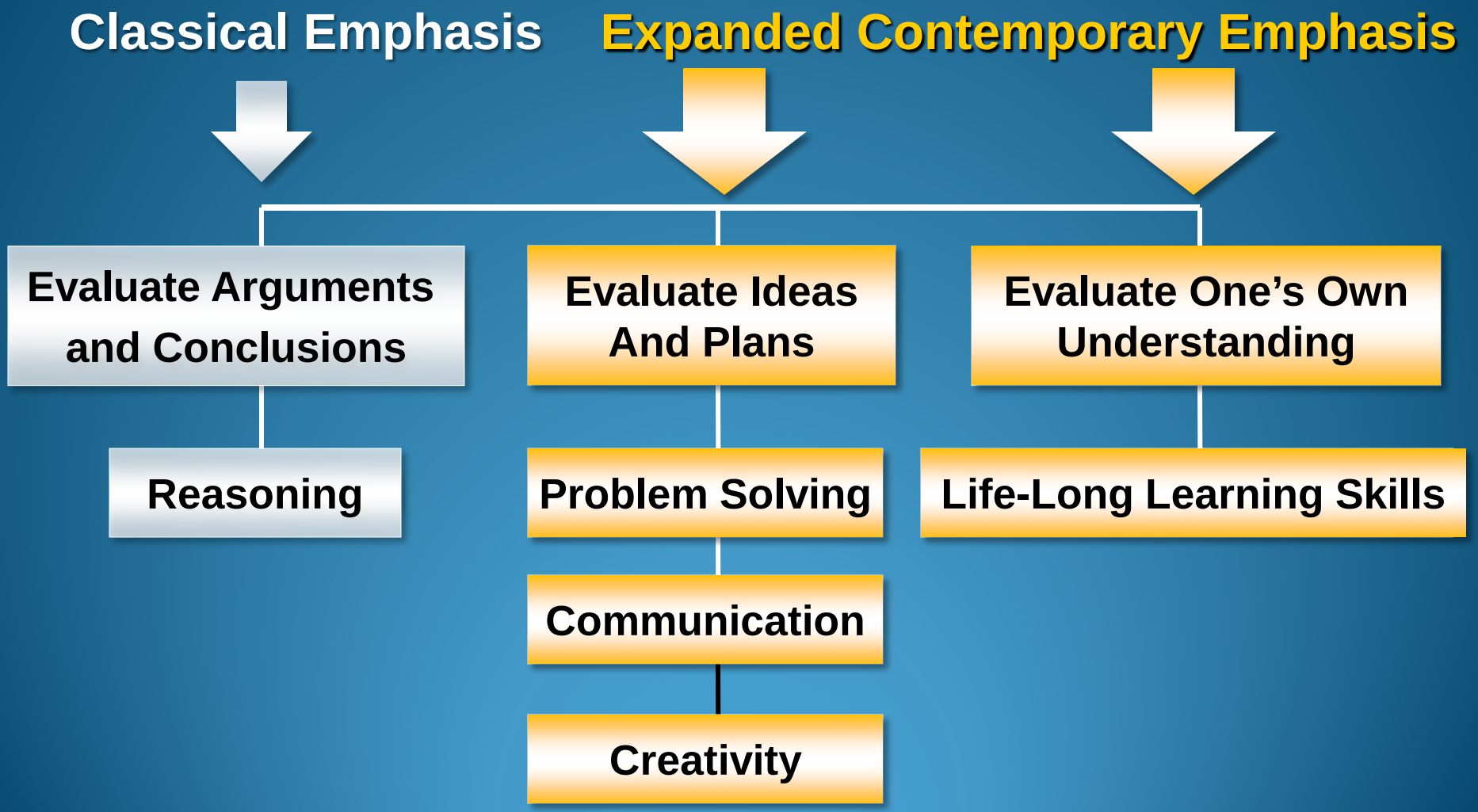


Why Assess Critical Thinking?

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

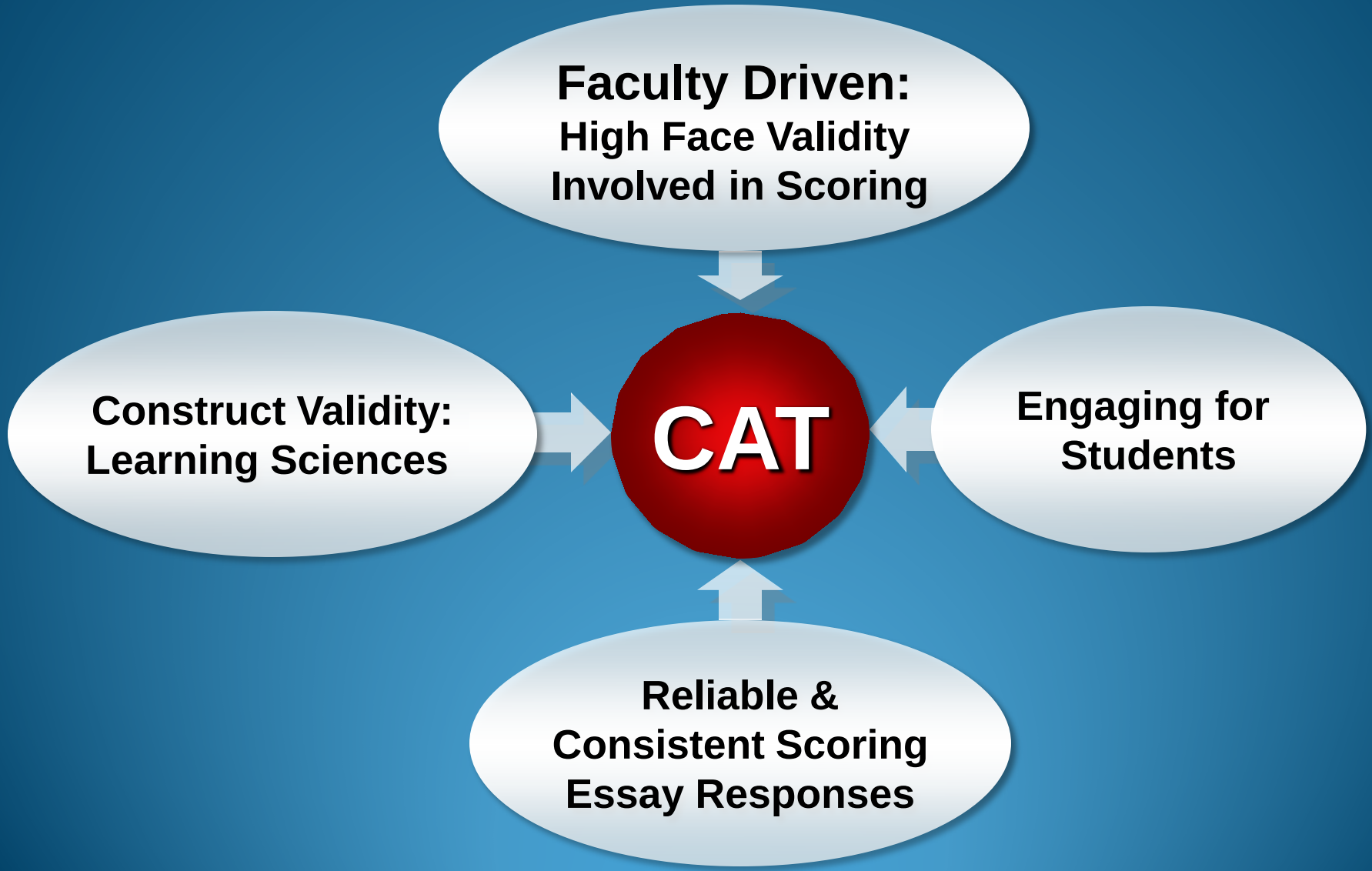
Collaborate With Other
Institutions To Refine CAT
2004 - 2007

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

Expand National Dissemination
& Support Assessment in NSF Projects
2010 - 2014

Over 100 Institutions Collaborating

Designing the CAT Instrument



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

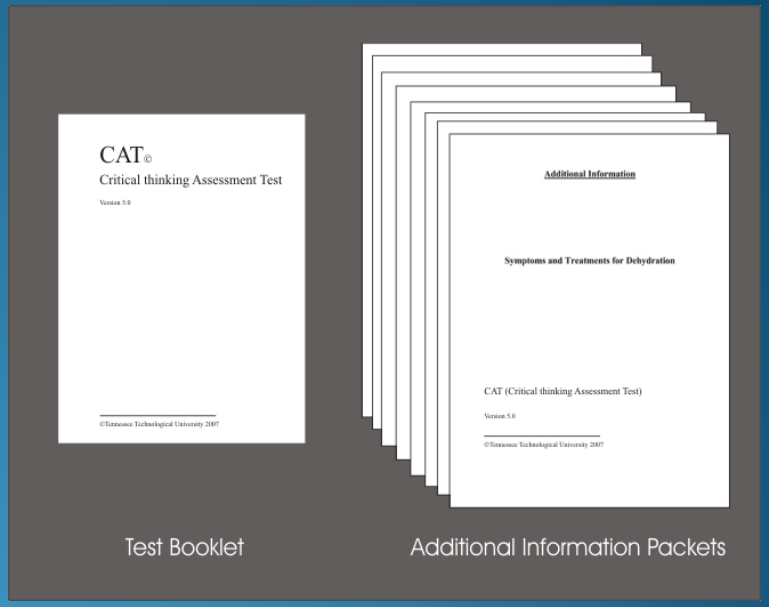
- Separate relevant from irrelevant information.
- Integrate information to solve problems.
- Learn & apply new information.
- Use mathematical skills to solve real-world problems.

Communication

- Communicate ideas effectively.

CAT Features

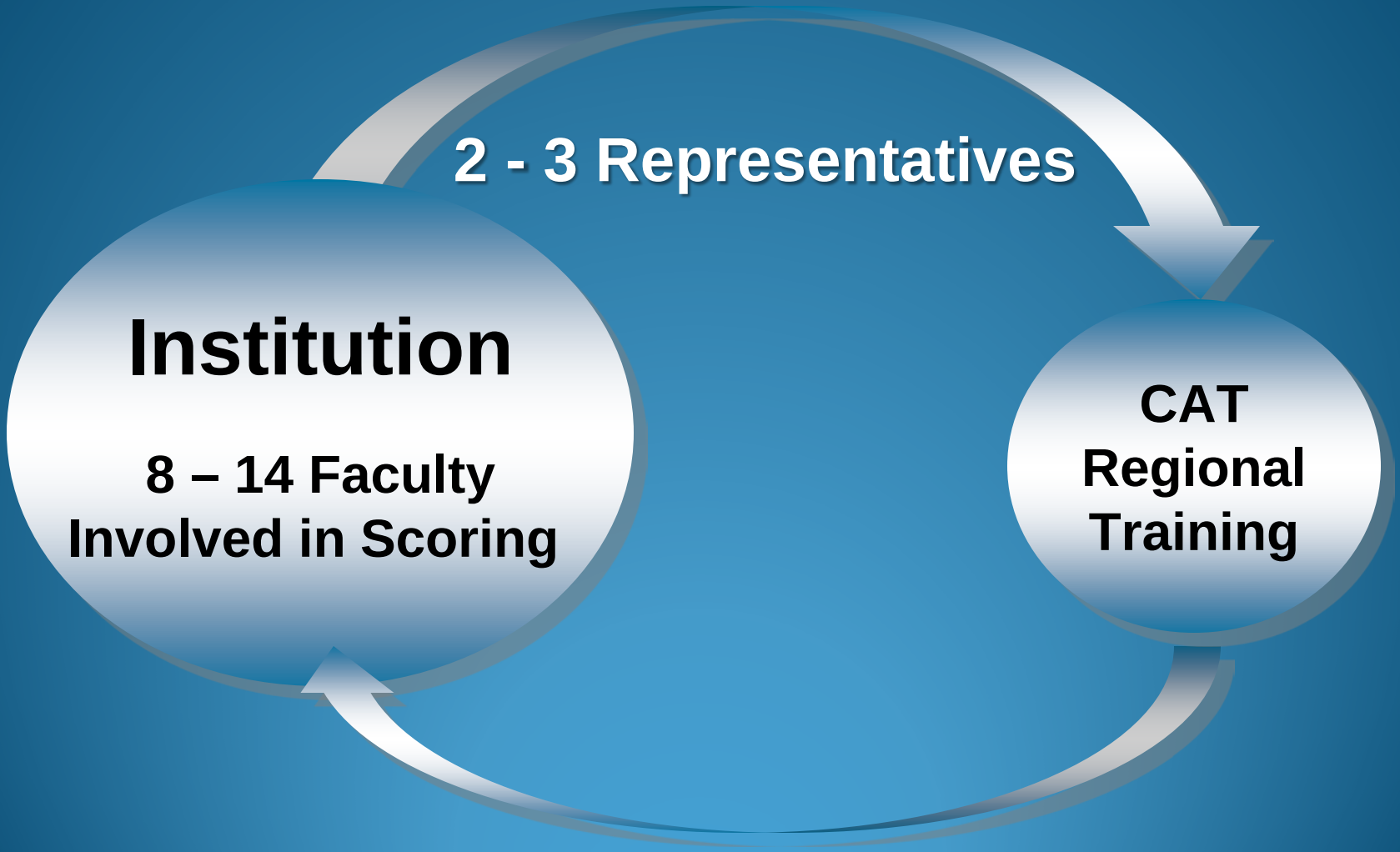
- One hour exam
- Mostly short answer essay
- Faculty scored in workshops
- Detailed scoring guide
- Reliable
- Valid



Cost

$6 Test, $200 Year Participation Fee

National Dissemination Model



Sample Disclosed Question

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

- 99.9% 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 presented by the scientist strongly support their theory? Yes ___ No____

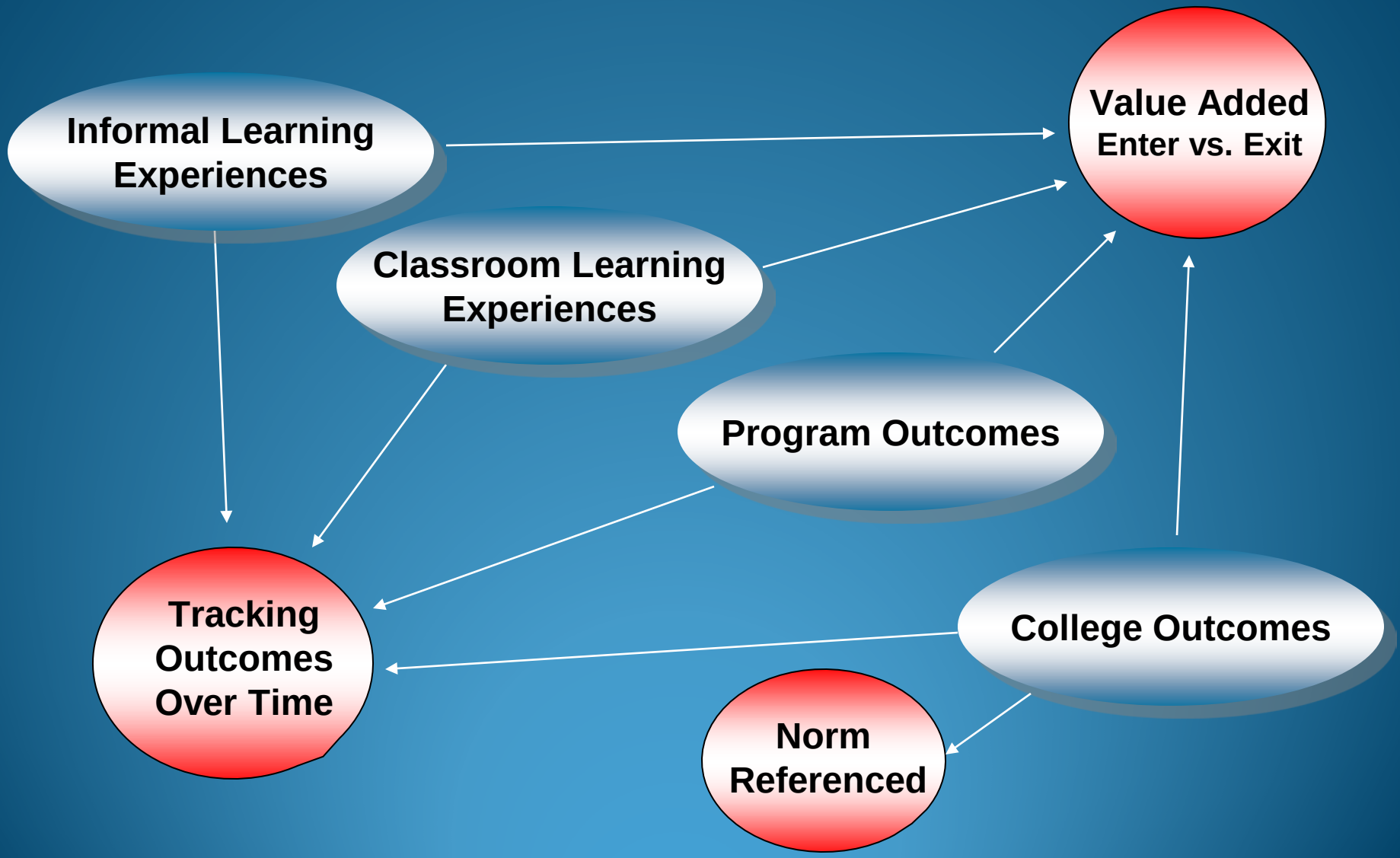
Are there other explanations for the data besides the scientist's theory? If so, describe.

_____

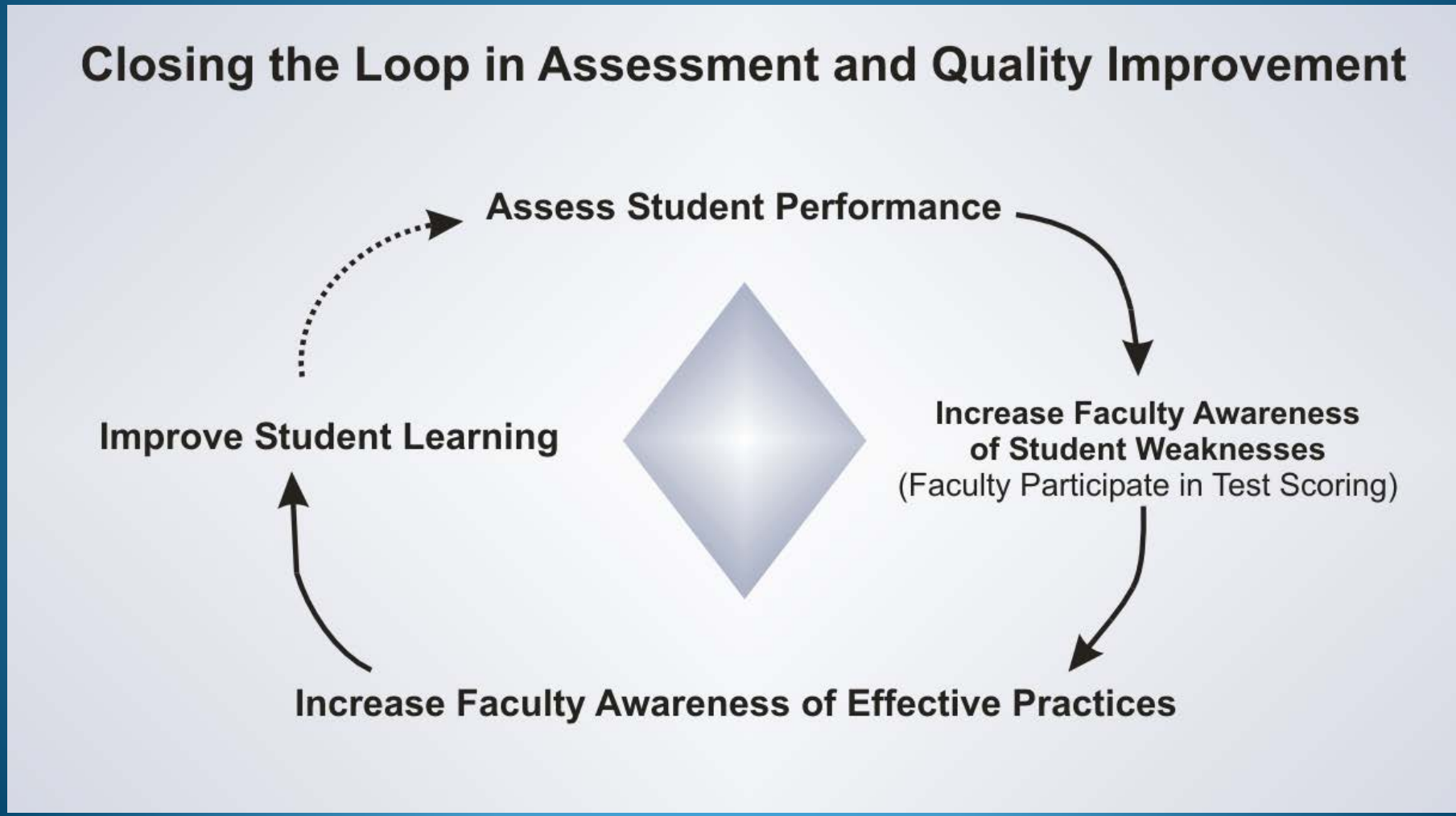
What kind of additional information or evidence would support the scientist's theory?

_____

Assessment Uses of CAT



Closing the Loop in Assessment and Quality Improvement



in depth

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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@clemsnon.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

Critical Thinking and Science Literacy Course Impact on Student Retention and Graduation

Susan K. Hippensteele, Ph.D., J.D.
University of Hawai`i at Manoa

3-pronged focus of the UHM project

1) Developing and evaluating "best practices" pedagogy for teaching critical thinking and science literacy through applied multidisciplinary general education courses

2) Building a broad multidisciplinary community of faculty with expertise in critical thinking and science literacy pedagogy that 'closes the loop between teaching, learning, and assessment

3) Evaluating the impact of freshman completion of a critical thinking and science literacy course on retention and progress to degree

1. SOCS 150: *Street Science: Analyzing and Applying Evidence in Daily Life*

- **Multi-disciplinary critical thinking and science literacy course**
- **Large enrollment (170 max) with Friday tutorials**
- **Six instructors from psychology, anthropology, economics, and women's studies**
- **Introduction to critical thinking and logic followed by 2-week problem based units; final research paper project**
- **Interactive classroom activities, individual and small group homework and quizzes, no content memorization—all skill based and applied problem-solving**

2. Critical Thinking and Faculty Development Model

- **CAT is used to assess critical thinking skill acquisition within experimental (SOCS 150) and control classes**
- **Pre- and post-test methodology**
- **Faculty scoring sessions engage faculty in meaningful discussion of *applied* critical thinking skill acquisition across disciplines**
- **Faculty scoring rubric serves as basis for discussion of teaching pedagogy across disciplines**
- **Significant outcome *appears to be* impact on faculty course development/modification**

3. Student Learning Research, Education Outcomes, and Progress to Degree

- **The original motive for developing SOCS 150 was to better prepare students for upper division coursework across multiple disciplines**
- **The literature on critical thinking suggests a broader utility so we developed a multi-year, cross college research project using the SOCS 150 course model to examine the impact of science literacy and critical thinking course completion on education outcomes and progress to degree**

What do we hope to achieve? Short term issues/goals

- Fall 2011 CAT pilot data were instructive from both a methodological and course development standpoint.
- Issue 1: random selection of tests from control classes.
- Issue 2: SOCS 150 pre- and post-test scores suggest the course needs to be refined (e.g., conceptual confusion among students as evidenced by inconsistent scores on questions designed to evaluate specific skills).
- Issue 3: SOCS 150 pre- and post test results suggest the rigor of the course can/should be increased.

What do we hope to achieve? Long term issues/goals

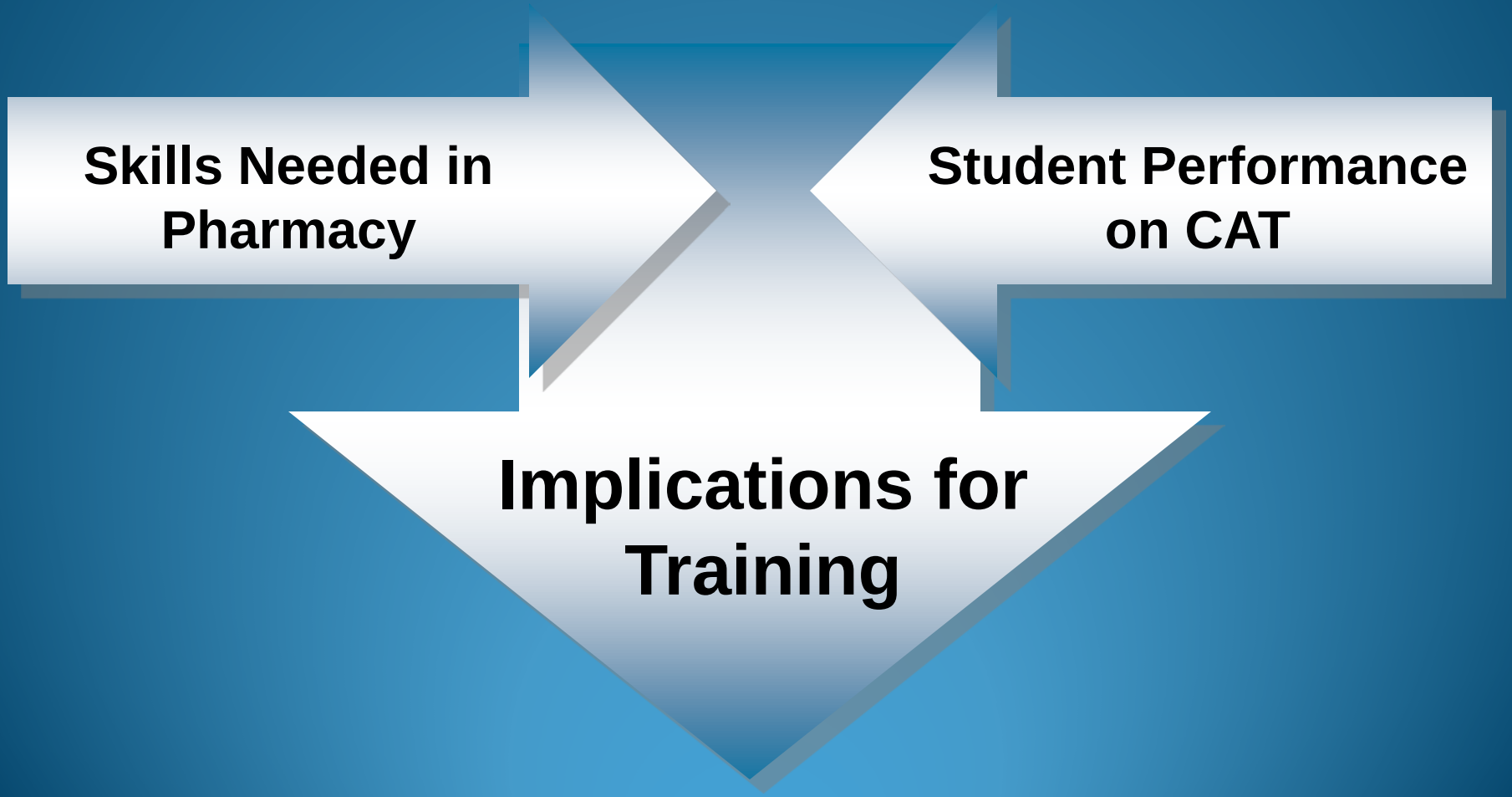
- We expect our multidisciplinary courses to enhance science literacy and critical thinking skills and improve retention across multiple disciplines.
- Semester by semester CAT pre- and post-test analysis will enable us to maintain an iterative approach to course refinement until we achieve a stable level of learning.
- A student data tracking system will enable us to identify the long term impact of freshman enrollment these courses (e.g., choice of major, progress to degree).

Using the CAT as a Diagnostic Tool and Learning Design Guide

David Hawkins, PharmD
Professor and Dean
California Northstate University
College of Pharmacy

Using the CAT as a Diagnostic Tool

California Northstate College of Pharmacy



Pharmacy Practice Skills that Require Good Critical Thinking Skills

1. **Design** empiric treatment for a clinical problem based on critical appraisal of published data.
2. **Defend** the pharmacotherapy management of a specific patient based on age, race, organ function, and concomitant conditions.
3. **Define** the desired therapeutic outcomes given the patient's underlying disease state and prognosis.
3. **Determine** the patient's clinical response to treatment and make adjustments when appropriate.
4. **Delineate** the possible causes of a patient's signs, symptoms, abnormal lab results, or failure to achieve expected treatment results.
5. **Differentiate** treatment options based on changes in a patient's disease, other treatments, or development of a new clinical problem.

   Detect medication errors, non-adherence, and drug-induced problems.

Critical Thinking Skills Assessed by the CAT that Are Important to the Practice of Pharmacy

- Provide alternative explanations for a pattern of evidence that has many possible causes.
- Identify additional information needed to evaluate a hypothesis/interpretation
- Provide relevant alternative interpretations of information
- Separate relevant from irrelevant information when searching for information to solve a problem.
- Identify suitable solutions for a real-world problem.
- Identify and explain the best solution for a real-world problem using relevant information.

Critical Thinking Skills in Need of Further Development

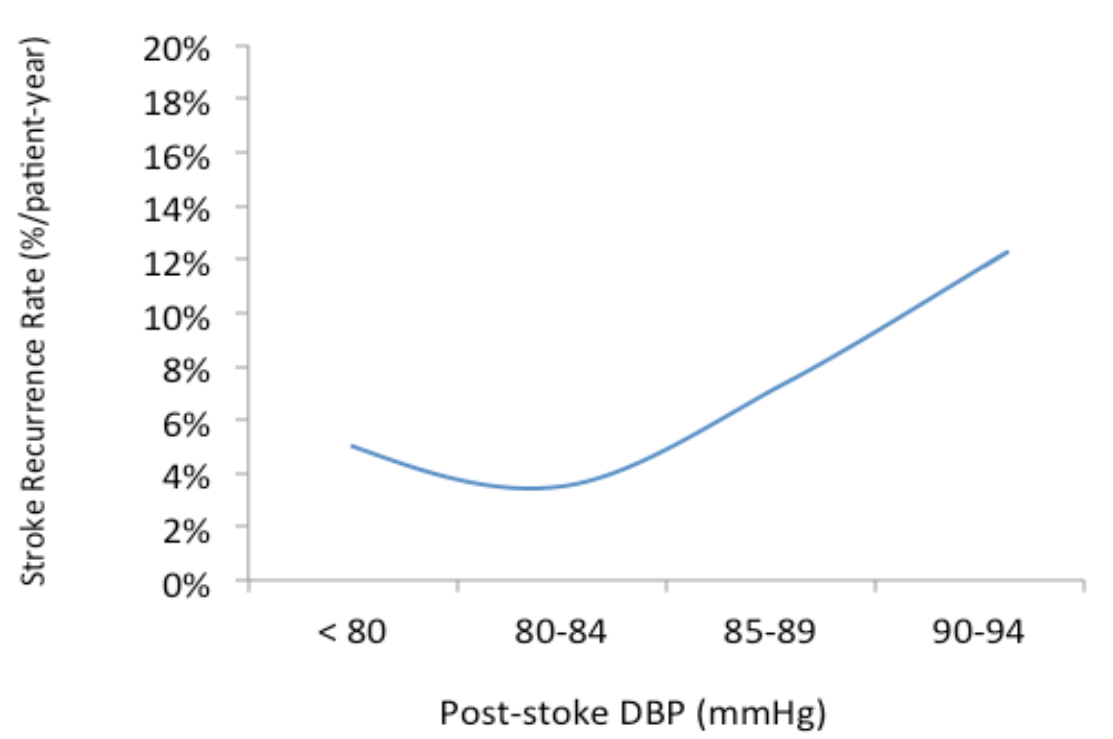
Critical Thinking Skill	Class 2012	Class 2013	Class 2014	Class 2015
Providing alternative explanations (0-3)	1.0	0.89	1.29	1.09
Additional information needed to evaluate a hypothesis (0-4)	1.92	1.51	1.78	1.50
Identify alternative solutions (0-3)	1.08	0.92	1.45	1.16
Identify best solution (0-5)	2.16	2.17	2.69	2.74

Using CAT as a Learning Design Guide

- Determine critical thinking skills in which students are most deficient at baseline
- Intentionally incorporate learning exercises throughout the curriculum that help students to further develop those skills
- Reassess critical thinking skills toward the end of the academic program

Q 1: Summarize the pattern of results in a graph without making inappropriate inferences.

What would you recommend in treating a patient with hypertension and a recent history of stroke based on the data presented in the graph below?



Q 3: Provide alternative explanations for a pattern of results that has many possible causes.

A 52 y/o male patient with a seizure disorder has been placed on 300mg of Dilantin daily. Despite this usual daily dose, the patient continues to have 1-2 seizures every 3-4 days.

What are three possible explanations for the lack of anticonvulsant effectiveness in this patient's Dilantin therapy?

Q 4: Identify additional information needed to evaluate a hypothesis

A patient with infective endocarditis was admitted to a hospital. Blood cultures were drawn revealing a gram-negative bacillus. Admitting hospital labs were all within normal limits except for an increased in serum creatinine. The patient was started on ceftriaxone and gentamicin. On the second hospital day, the patient's renal function declined markedly and he developed hematuria and heavy albuminuria. Gentamicin was discontinued because it is known to cause acute nephritis characterized by decreased renal function along with the detection of blood and albumin in the urine.

How likely is the hypothesis that gentamicin caused the kidney problem?

This case illustrates two points concerning temporal eligibility of a drug-induced problem.

1. **In order for a drug to cause a problem its initiation must precede the onset of the problem.**
2. **Usually the onset of gentamicin-induced kidney toxicity begins after the 4^{th} or 5^{th} day of therapy.**

A more likely cause for the patient's sudden onset of kidney disease is an immune-complex reaction triggered by the infective endocarditis.

Q10: Separate relevant from irrelevant information when solving a real-world problem.

Which of the following patient factors would you need to consider in dosing a patient with heart failure on digoxin for symptomatic relief?

A. Age
B. Gender
C. Race
D. Weight
E. Height
F. Serum creatinine
G. Serum sodium
H. Serum bilirubin

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B. Gender
C. Race
D. Weight
E. Height
F. Serum creatinine
G. Serum sodium
H. Serum bilirubin

Maintenance doses of digoxin are calculated based on the patient's age, gender, height, weight, and serum creatinine.

Q14: Identify and explain the best solution for a real-world problem using relevant information.

A 62 y/o African American woman with newly diagnosed hypertension is being managed on 25 mg of Hydrochlorothiazide (HCTZ) daily. The patient has a history of acute gouty arthritis. She read on WebMD that HCTZ can precipitate an acute attack of gout.

What alternative medication can be used to manage her hypertension?

Baseline –Post Test Scores

Skill Assessed	Baseline Mean	Post Test Mean	Effect Size
Interpreting Graphs	0.62	0.78	+0.34*
Provide Alternative Explanations	1.03	1.56	+0.54***
Spurious Information supports Hypothesis	0.82	0.92	+0.31*
Separate Relevant vs Irrelevant	2.92	3.23	+0.36*
Apply relevant information to evaluate problem	1.30	1.05	-0.40**
* p<.05, ** p<.01, *** p<.001			

		GPA	Pre-Reg GPA	Native Language	Pharmacy Tech License
CAT Score	Pearson Correlation	-.007	-.054	.284**	.084
	Sig. (2-tailed)	.950	.613	.007	.432
	N	90	90	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Degree Granting College System

		UCSys	CSUSys	OtherSys
CAT Score	Pearson Correlation	.197	-.124	-.121
	Sig. (2-tailed)	.063	.242	.257
	N	90	90	90

Correlations

Correlation Between Baseline CAT Scores and Cumulative GPA

	Mean	Std Deviation	N
Baseline CAT Score	20.09	5.004	80
Cumulative GPA		0.396	80

Pearson Correlation = 0.235, p=0.036

Thank You

CAT National Dissemination Project

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.