

Measuring Gains in Scientific Thinking Using the Experimental Design Ability Test (EDAT)

ASMCUE 2010, San Diego
Microbrew

Karen Sirum, Asst. Prof., Dept. of Biological Sciences,
Bowling Green State Univ., OH
ksirum@bgsu.edu

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Abstract:

Undergraduate science education goals include development of students' scientific thinking skills. Scientific thinking is an aspect of rational thinking, and currently used and accepted intelligence tests such as IQ, GRE, SAT, and placement tests do not measure rational thinking. Yet, in terms of helping people make decisions that help them attain their goals, rationality is even more important than "intelligence". A new assessment instrument called the Experimental Design Ability Test (EDAT), is used to measure students' understanding of the criteria for good experimental design through their open-ended response to a prompt grounded in everyday life science problems. The EDAT can be administered in a pre/post test format to measure gains, is content independent, and only takes 10-12 minutes of class time to administer. Consistent and rapid evaluation of student responses is accomplished using a simple and specific 10-point scoring rubric that identifies whether students include each of 10 key aspects of experimental design. EDAT scores serve as a diagnostic, indicating which areas are in need of further instruction, because the scoring rubric is hierarchical: the 10th point is less frequently included in student responses than the first and if, for example, a student scores a "5", that generally means only items 1-5 were included. In this mini workshop session, participants will have the opportunity to use and critique the EDAT, and hear about how it has been used in biology classrooms and labs of all sizes and at all levels. The novel feature of the EDAT is that it assesses not only what students know about the scientific method, but it probes understanding based on what students are able to do. I have found that basic experimental design can be taught and gains in EDAT scores can be achieved, even in the non-majors introductory biology classroom.

“smart” but still act foolishly

- We all know people who are considered “smart” but still act foolishly, including students we graduate. The smart part we can name, IQ, hi SATs, GREs, but what is the other part?
- It’s called Rational Thinking (RT). Difficult to measure rationality but We know it when we see it. Much easier to measure when it is being violated
- Ref: “What Intelligence Tests Miss”, Stanovich

IQ and RT no correlation

- **Typical measures of intelligence such as IQ do not correlate with rational thinking**
- **There are specific knowledge structures that are required to think and act rationally**
 - These are the rules, knowledge, procedures, and strategies that a person can retrieve from memory in order to aid decision making and problem solving.

Ref: “What Intelligence Tests Miss”, Stanovich

Basic Tools of Rationality

- Probabilistic thinking
- Logic
- **Scientific reasoning***

*This is where we as science teachers come in

50% of students with >average SAT score are lacking in RT skills

- **More than half of university students with a greater than average SAT are lacking in these types of mindware**
- Explicit training in rational thought spotty and inconsistent.

Ref: "What Intelligence Tests Miss", Stanovich

Criteria Desired for Scientific Thinking Assessment Instrument

- Not time consuming for students
- Based on a practical challenge from an “everyday life” problem (buy-in)
- Open ended to reveal student’s thinking (not multiple choice)
- Easy to score consistently (inter- and intra-rater reliability)
- Provides quantitative measure

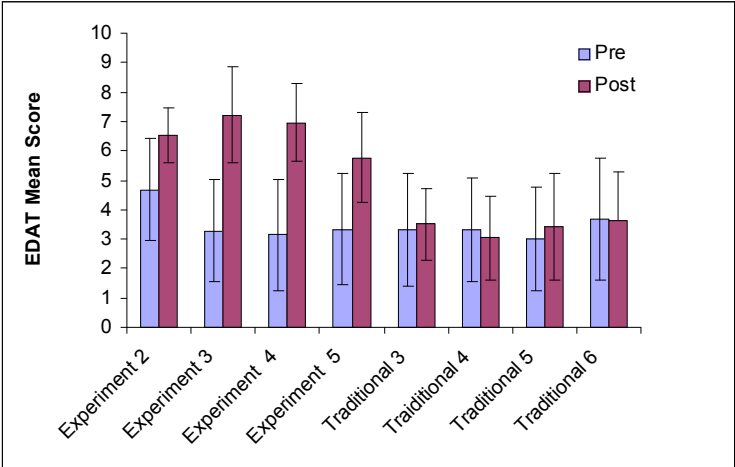
Experimental Design Ability Test (EDAT)

- Pre/post test

Open ended prompt for experimental design that is scored with specific hierarchical rubric I developed. Max score=10

Used EDAT in 4 sections of transformed intro biology course with inquiry labs and student designed experiments, and in 4 traditional sections of course with “cookbook” descriptive labs

EDAT Results

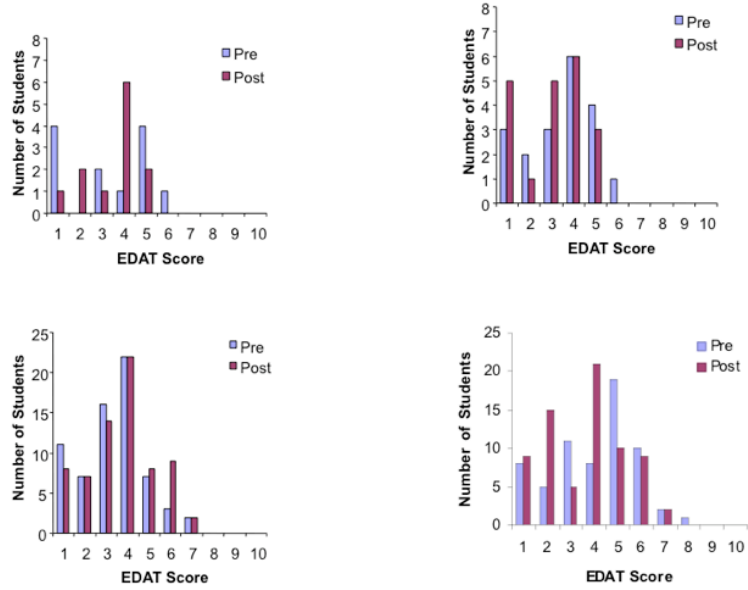


- All experimental groups made statistically significant gains ($p < 0.001$)
- Traditional groups did not make significant gains.

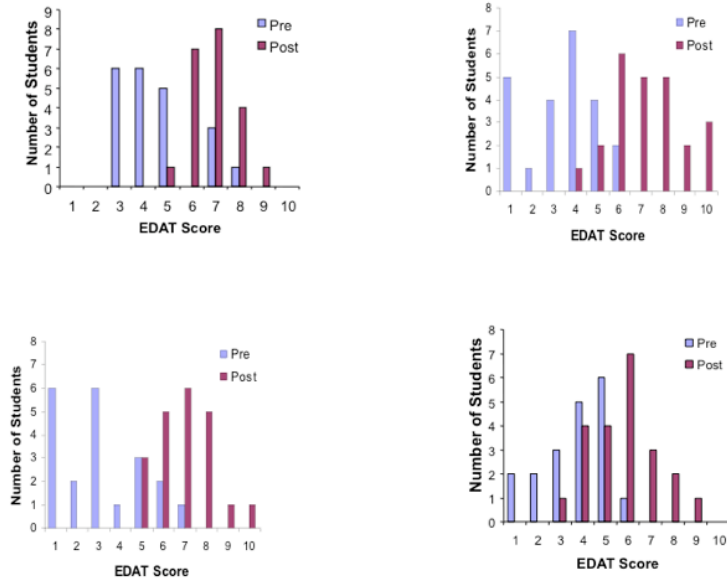
Distribution of EDAT Scores

EDAT Score	Number with this score
0	0
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Distribution of EDAT Scores: Traditional Teaching Groups



Distribution of EDAT Scores: Experimental Teaching Groups



Non Majors Intro Biology EDAT Scores Independent of:

- Age
- Year in College
- Gender

AND

- Posttest score independent of pretest score

Conclusion

- Introductory non majors students, explicitly trained in experimental design through self designed lab experiments, critique of science reports in the media, and scientific thinking group problem solving, improve in **scientific** thinking as measured by the EDAT.