Today’s webinar
The challenges of assessing critical thinking

What is critical thinking?

Do we need to explicitly teach critical thinking?

What are some best practices when it comes to teaching and assessing students’ critical thinking skills?
Meet today’s experts

Ruth Rodgers is an Educational Development Consultant with over thirty years of experience in teaching and developing faculty in the post-secondary environment.
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Pat Croskerry is a Professor in Emergency Medicine and Director of the Critical Thinking Program at Dalhousie Medical School in Halifax, Nova Scotia.
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Brian Frank is the Director of Program Development in the Faculty of Engineering and Applied Science at Queen’s University, and co-lead on a HEQCO project that is measuring critical thinking development.
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Ruth Rodgers, B.A., B.Ed., M.C.E.

Educational Development Consultant
Why critical thinking?

Information ubiquitous and overwhelming in quantity—changes our role.

Must teach students to

ask the right questions;

seek out answers from varied sources;

assess the validity of the answers;

apply the answers to unique problems.
Why is this important now?

Current parenting styles
Extended childhood
% of students in post-secondary

vs

Modern career requirements
The challenges of developing critical thinking ability

Requires overt teaching and much practice = time

Facile acceptance of shallow reasoning

Pace of life/learning

Consumer mentality

Distractions and limitations
Critical thinking can be
– analytical or persuasive in the realm of theory
– applied and practical in the realm of problem solving

Critical thinking requires both
– analysis (breaking apart)
– synthesis (putting together)

Both university and college settings require both types of critical thinking.
What does critical thinking look like?

Successful critical thinking can be judged by its results:

– problem definition;
– resources/opinions/solutions from credible and relevant sources;
– source material judged in context;
– conclusion integrates source material but responds to uniqueness;
– conclusion successfully addresses the presenting problem or question.
How is critical thinking taught?

• Defining the problem
  – overt teaching by example and practice

• Seeking resources
  – search processes and criteria

• Judging resources
  – logical fallacies/cognitive biases/thinking exercises
  – discipline-specific credentials or measures
    • case studies, class exercises, librarian assistance

• Applying resources/problem solving
  – case studies, group projects, applied research, charettes
  – essays, reports, debates, presentations
How is critical thinking evaluated?

• Formative assessment
  – professor feedback on interim steps
    • proposals, resource lists, progress reports, project outlines
  – peer review and practice opportunities
    • debates, round tables, traveling files
  – rubric includes “evidence of critical thinking”

• Summative evaluation
  – against criteria specific to task PLUS evidence of critical thinking
Sample project: persuasive presentation

- **Hero’s Journey** course
  - *Star Wars, Lord of the Rings, Harry Potter*
- Literary elements (plot, setting, theme, character)
- Determine whether the FILM or BOOK version of the chosen title fulfills the literary element better
  - proposal with preliminary resource list and thesis (analysis)
- Select evidence to defend your thesis
  - Assess validity of source material: fans, critics, filmmakers, authors (analysis)
  - progress report with refined thesis statement, project outline, and finalized bibliography (synthesis)
- Generate a multi-media presentation supporting your point of view (synthesis)
Follow-up: open book exam

All presentations posted
Exam questions given one week ahead

One potential question (analysis + synthesis):

In what ways does the medium of modern film enable filmmakers to exceed the literary potential of a book? In what ways is the medium of film a limitation of an author’s expression? Draw upon all three of our target stories to support your response, and integrate the work of your fellow students from their posted presentations.
Final thoughts

Both overt and embedded.

Must master the steps and techniques of critical thinking.

Must be modeled and practiced repeatedly.

Formative and summative evaluation needed.

Requires willingness to be vulnerable, flexible, open to risk, from both teacher AND student.
Critical Thinking at Dalhousie Medical School

Pat Croskerry MD, PhD, FRCP(Edin)

HEQCO Webinar
Nov 26 2015
The most important thing that doctors do is diagnosis
Diagnostic Failure

15%
Estimated number of preventable hospital deaths due to diagnostic failure annually in the US
Estimated number of preventable hospital deaths due to diagnostic failure annually in the US

40,000 – 80,000

Leape, Berwick and Bates  JAMA 2002
Why does misdiagnosis occur?

- The system (25%)
- The individual (75%)
Individual

- Doesn’t try hard enough
- Doesn’t know enough
- Doesn’t think right
Critical Thinkers Routinely Apply Intellectual Standards To The Elements Of Reasoning In Order To Develop Intellectual Traits

**The Standards**
- Clarity
- Accuracy
- Relevance
- Logicalness
- Breadth
- Precision
- Significance
- Completeness
- Fairness
- Depth

**The Elements**
- Purposes
- Questions
- Points of view
- Information
- Inferences
- Concepts
- Implications
- Assumptions

**Intellectual Traits**
- Intellectual Humility
- Intellectual Autonomy
- Intellectual Integrity
- Intellectual Courage
- Intellectual Perseverance
- Confidence in Reason
- Intellectual Empathy
- Fairmindedness

As we learn to develop

Must be applied to
The Stages of Critical Thinking

- **Stage One:** The Unreflective Thinker
- **Stage Two:** The Challenged Thinker
- **Stage Three:** The Beginning Thinker
- **Stage Four:** The Practicing Thinker
- **Stage Five:** The Advanced Thinker
- **Stage Six:** The Accomplished Thinker

*Elder and Paul, 2010*
The Critical Thinking Program at Dalhousie Medical School
CT stages at Dalhousie

- Stage 1: by the end of Med 1
- Stage 2: by the end of Med 2
- Stage 3: between Med 3 and Med 4
Do critical thinkers actually make better decisions?
Do critical thinkers actually make better decisions?

YES!
Can you teach it?

*UK Thinking Skills Review Group (2005)*

- Examined 6500 sources – chapters, articles, papers
- Age range 5-16yrs
- 191 had all necessary information
- 23 identified as ‘highly relevant’- in depth analysis
Results

• Majority of interventions - positive impact
• None reported a negative impact
• Effect relatively greater than most other researched educational interventions
Results

CT skills programmes and approaches improved performance on tests of cognitive measures with an overall effect size of 0.62. This effect would move a class ranked at 50th place in a league table of 100 similar classes to 26th or a percentile gain of 24 points.
Integrated approach

- Undergraduate curriculum
- Tutor and Instructor development
- Postgraduate training
- Faculty development
- Continuing Medical Education
The Ethical Imperative to Think about Thinking

Diagnostics, Metacognition, and Medical Professionalism

MEREDITH STARK and JOSEPH J. FINS

Abstract: While the medical ethics literature has well explored the harm to patients, families, and the integrity of the profession in failing to disclose medical errors once they occur, less often addressed are the moral and professional obligations to take all available steps to prevent errors and harm in the first instance. As an expanding body of scholarship further elucidates the causes of medical error, including the considerable extent to which medical errors, particularly in diagnostics, may be attributable to cognitive sources, insufficient progress in systematically evaluating and implementing suggested strategies for improving critical thinking skills and medical judgment is of mounting concern. Continued failure to address pervasive thinking errors in medical decisionmaking imperils patient safety and professionalism, as well as beneficence and nonmaleficence, fairness and justice. We maintain that self-reflective and metacognitive refinement of critical thinking should not be construed as optional but rather should be considered an integral part of medical education, a codified tenet of professionalism, and by extension, a moral and professional duty.

Keywords: medical decision making; medical ethics; professionalism; medical education; medical error; diagnostic error; patient safety; cognition; judgment; metacognition

No longer an option...
Development of efficacy of decision making

Critical thinking (CT) and clinical decision making (CDM)

Knowledge
Accessibility
Relevance
Completeness
Reliability
Critical thinking (CT) and clinical decision making (CDM)

Development of efficacy of decision making

Knowledge
Accessibility
Relevance
Completeness
Reliability

Standards of CT
Clarity
Accuracy
Relevance
Logicalness
Breadth

Precision
Significance
Completeness
Fairness
Depth
Critical thinking (CT) and clinical decision making (CDM)

Development of efficacy of decision making

Understanding of CDM

Knowledge
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Fairness
Depth
Development of efficacy of decision making

Critical thinking (CT) and clinical decision making (CDM)

Understanding of CDM

Understanding and detection of cognitive bias

Knowledge
- Accessibility
- Relevance
- Completeness
- Reliability

Standards of CT
- Clarity
- Accuracy
- Relevance
- Logicalness
- Breadth
- Precision
- Significance
- Completeness
- Fairness
- Depth
Development of efficacy of decision making

Critical thinking (CT) and clinical decision making (CDM)

Understanding of CDM

Knowledge
Accessibility
Relevance
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Reliability

Understanding and detection of cognitive bias

Understanding and detection of logical fallacies

Standards of CT

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- Depth

Understanding of CDM

Understanding and detection of cognitive bias

Understanding and detection of logical fallacies

Mindware available for debiasing

Critical thinking (CT) and clinical decision making (CDM)
Development of efficacy of decision making

Critical thinking (CT) and clinical decision making (CDM)

- Understanding of CDM
- Understanding and detection of cognitive bias
- Understanding and detection of logical fallacies
- Mindware available for debiasing

Knowledge
Accessibility
Relevance
Completeness
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Standards of CT
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Patient Preferences
Critical thinking (CT) and clinical decision making (CDM)

Development of efficacy of decision making

Understanding of CDM

Understanding and detection of cognitive bias

Understanding and detection of logical fallacies

Mindware available for debiasing

Knowledge
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Patient Preferences

Mindfulness
Summary

• Critical thinking (CT) improves reasoning
• CT must be integral in clinical reasoning
• Significant gains can be made in CT by training
• It should be explicit (not implicit or tacit)
• The earlier the better for an intervention?
• Current medical training may suppress it?
• It’s not too late in UGME, PGME, and CME
• It is an ethical imperative
Assessing critical thinking

1. Can we measure development over time?
2. What are the issues in assessment?
## Assessment approaches

<table>
<thead>
<tr>
<th></th>
<th>Inside course</th>
<th>Outside course</th>
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<tbody>
<tr>
<td><strong>Multiple choice</strong></td>
<td></td>
<td>Standardized tests:</td>
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<tr>
<td></td>
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<td>• Cornell Level Z</td>
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<td></td>
<td>• California Test CT</td>
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<tr>
<td><strong>Open response</strong></td>
<td>Assignments scored by common rubrics</td>
<td>Standardized tests:</td>
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<tr>
<td></td>
<td></td>
<td>• CLA+</td>
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<td>• CAT</td>
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<td></td>
<td></td>
<td>• International CT</td>
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</tbody>
</table>
STUDY 1: CRITICAL THINKING IN FIRST YEAR ENGINEERING
Measure CT with standardized tests and course outcomes over a semester

**Cohort A**
- **CLA**: X
- **N/A**

**Cohort B**
- **CLZ**: X
- **CLZ**

**Cohort C**
- **ICTET**: X
- **CLZ**

**Cohort D**
- **ICTET**: X
- **ICTET**

**Cohort E**
- **CLZ**: X
- **ICTET**

**CLA** = Collegiate Learning Assessment
**CLZ** = Cornell Level Z
**ICTET** = International Critical Thinking Test
Standardized tests results:

Cornell Level Z: 
No significant change

International CT:
No significant change

Course report scores:

Significant development
Standardized tests results:

Cornell Level Z:  
*No significant change*

International CT:  
*No significant change*
STUDY 2: LEARNING OUTCOMES ASSESSMENT CONSORTIUM
Assessment of Cognitive Skills
Critical thinking; Problem Solving; Written Communication; Lifelong Learning

Today

1. Online Test (CLA+)
2. Paper Test (CAT)
3. Survey

Standardized Measurement

Meta-rubric Assessment

Qualitative Performance Evaluation

Course Embedded Assessment

Coded to frameworks

Course-based artifacts

VALUE Rubrics
Longitudinal study

### Faculty of Arts and Science:
- Psychology
- Drama
- Physics

### Faculty of Engineering and Applied Science:
- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Engineering Physics
- Geological Engineering
- Math Engineering
- Mechanical Engineering
- Mining Engineering
- Inter-disciplinary Engineering

<table>
<thead>
<tr>
<th>Year</th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
<th>4th Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013/14</td>
<td>n = 1960</td>
<td></td>
<td></td>
<td>n = 145</td>
</tr>
<tr>
<td>2014/15</td>
<td>-</td>
<td>n = 803</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2015/16</td>
<td>-</td>
<td>-</td>
<td>TBA</td>
<td>-</td>
</tr>
</tbody>
</table>
Assessment of Cognitive Skills

Critical thinking; Problem Solving; Written Communication; Lifelong Learning

- Standardized Measurement
- Qualitative Performance Evaluation
- Meta-rubric Assessment
- Course Embedded Assessment

Coded to frameworks

VALUE Rubrics

Course-based artifacts
CLA+ (critical thinking, communication)

Benchmarking

1st Year - 90th Percentile

4th Year - 98th Percentile

- Exiting 4th Year means from all participating 4-Year Colleges and Universities
- Queen’s University 1st Year ($\mu=1169$) n=546
- Queen’s University 4th Year ($\mu=1258$) n=41
Change over 1 year

**CAT**

**CLA+**

CLA Mastery Levels
- Advanced
- Accomplished
- Proficient
- Basic
- Below Basic

CAT Scores
- First Year: n = 89, n = 167
- Second Year: n = 105, n = 353

CLA+ Scores
- First Year: n = 269, n = 240
- Second Year: n = 97, n = 174
- Third Year: n = 0, n = 0
- Fourth Year: n = 0, n = 40

Legend:
- Arts and Science
- Engineering and Applied Science
Assessment of Cognitive Skills
Critical thinking; Problem Solving; Written Communication; Lifelong Learning

- Standardized Measurement
- Qualitative Performance Evaluation
- Course Embedded Assessment
- Meta-rubric Assessment

Coded to frameworks
VALUE Rubrics
Course-based artifacts
VALUE Rubric Assessment

Critical Thinking

- Explains issue or problem, provides relevant information necessary for understanding
- Selects and uses information to investigate a point of view
- Adopts a specific position in arguments, acknowledges diverse points of view
- Analyzes own and others' assumptions and evaluates the relevance of context
- Evaluates consequences and implications of conclusions
Scoring

Student demonstrates awareness of the ethical impacts of a study involving alcohol, but does not discuss the ramifications.

Conclusion is tied to information presented throughout; some related and relevant implications and outcomes are identified (e.g. reliability, publishing for scholarly community).
CT on reports measured by VALUE rubrics by department

Critical Thinking Dimension

Conclusions and outcomes
Student' position
Context and assumptions
Use of evidence
Explanation of issues

Rubric score

1 1.5 2 2.5 3

1 1.5 2 2.5 3

1 1.5 2 2.5 3

1 1.5 2 2.5 3

Year 2 Mean
Year 1 Mean

Year 2 Mean
Year 1 Mean

Year 2 Mean
Year 1 Mean

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Year 2 Mean
Year 1 Mean
Development of Critical Thinking demonstrated on course activities, scored on VALUE rubrics

Learning Outcome
- Explanation of Issues
- Evidence
- Influence of Context and Assumptions
- Student's Position
- Conclusions

First Year: n = 491
Second Year: n = 234
Third Year: n = 0
Fourth Year: n = 249
Development of Critical Thinking demonstrated on course activities, scored on VALUE rubrics

First Year: n = 491
Second Year: n = 234
Third Year: n = 0
Fourth Year: n = 249

Rubric Level

Learning Outcome
- Explanation of Issues
- Evidence
- Influence of Context and Assumptions
- Student's Position
- Conclusions
ISSUES...
Time and self-reported effort on CLA related to performance

**First Year**

- **Effort:** $y = 1045 + 36.4 \cdot x$, $r^2 = 0.0564$

- **Time:** $y = 1031 + 2.15 \cdot x$, $r^2 = 0.0562$

**Second Year**

- **Effort:** $y = 1015 + 48.7 \cdot x$, $r^2 = 0.0936$

- **Time:** $y = 981 + 3.25 \cdot x$, $r^2 = 0.171$
### Comment from scorers points to alignment problem

<table>
<thead>
<tr>
<th>Department -&gt;</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation of Issues:</strong></td>
<td>Reasoning was not elaborated on</td>
<td>Provided background and clarification</td>
<td>Described the social, environmental, and economic aspects</td>
</tr>
<tr>
<td><strong>Evidence:</strong></td>
<td>Were not asked to explore sources (used information provided at face value)</td>
<td>Used credible sources connected to the problem</td>
<td>Used credible sources to support their ideas</td>
</tr>
<tr>
<td><strong>Context and Assumptions</strong></td>
<td>Were not asked to explain assumptions</td>
<td>Described any assumptions they made to simplify the problem</td>
<td>Explained feasibility of implementing their prototype in the real world</td>
</tr>
<tr>
<td><strong>Student’s Position:</strong></td>
<td>Not assessed</td>
<td>Discussed the performance and included objective information</td>
<td>Discussed the performance of their product and included objective information</td>
</tr>
<tr>
<td><strong>Conclusions and Outcomes:</strong></td>
<td>Not assessed</td>
<td>Discussed positives of design, choosing information to fit their desired conclusion</td>
<td>Short conclusion, did not fully address problems or issues</td>
</tr>
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</table>
Critical thinking among engineering students
OUR THOUGHTS
What is it that the students are going to be doing? (Please select one)

- Researching, planning, producing and reflecting (Creative Thinking)
- Designing, implementing and evaluating (Problem Solving)
- Investigating, transferring understanding and reflecting (Critical Thinking)

Continue
Complete the following statement

This assignment is about... (E.g. creative writing; bridge failure; light waves; political campaigning)

research design

Continue
What dimensions do you want to assess? (click all that apply)

- Define problem
- Strategies
- Solution / hypothesis
- Evaluation
- Implementation
- Outcomes / implications

Note: the rubric criteria are describing intellectual skills, content areas that you might want to assess need to be added

Continue
### What aspects of these components are relevant to your task?

What aspects of the assessment dimensions do you want to assess? (select all that apply)

<table>
<thead>
<tr>
<th>Define problem</th>
<th>Problem</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>Strategies</td>
<td>Design</td>
<td>Procedures</td>
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<tr>
<td>Solution / hypothesis</td>
<td>Product</td>
<td>Solution</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Impacts</td>
<td>Contexts</td>
</tr>
<tr>
<td>Implementation</td>
<td>Logical arguments</td>
<td>Feasibility issues</td>
</tr>
<tr>
<td>Outcomes / impl</td>
<td>Confounds / sources of error</td>
<td></td>
</tr>
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</table>

Note: the rubric criteria

**Submit**
### Assignment: "research design"

<table>
<thead>
<tr>
<th>Step 1</th>
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<th>Step 3</th>
<th>Step 4</th>
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<tbody>
<tr>
<td><strong>Problem Solving</strong></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Define problem</strong></td>
<td>Describes the purpose as related to research design</td>
<td>Explains the purpose as related to research design</td>
<td>Analyzes purpose, contextually appropriate to research design</td>
<td>Evaluates the contextually diverse nature of the purpose applied to research design</td>
</tr>
<tr>
<td><strong>Strategies</strong></td>
<td>Lists strategies and procedures that might be used for solving the problem</td>
<td>Uses a single strategies and procedures appropriate to finding a solution</td>
<td>Incorporates multiple strategies and procedures to find a solution</td>
<td>Adapts strategies and procedures to allow for complexities when finding a solution</td>
</tr>
<tr>
<td><strong>Solution / hypothesis</strong></td>
<td>Presents simplistic design and hypothesis that partially address the problem</td>
<td>Presents satisfactory design and hypothesis addressing the problem</td>
<td>Presents coherent design and hypothesis tailored to the problem</td>
<td>Presents elegant design and hypothesis comprehensively addressing the problem</td>
</tr>
<tr>
<td><strong>Evaluation</strong></td>
<td>Identifies some contexts, feasibility issues, and confounds / sources of error that relate to the problem</td>
<td>Explains contexts, feasibility issues, and confounds / sources of error when addressing the problem</td>
<td>Assesses contexts, feasibility issues, and confounds / sources of error when solving the problem</td>
<td>Evaluates contexts, feasibility issues, and confounds / sources of error when solving the problem</td>
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## Learning Outcomes Project

### Building Assessment Scaffolds for Intellectual Skills

Your rubric has been saved! Download your rubric in CSV format.

**Assignment: "research design"**

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
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<th>Step 4</th>
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<th>Complete</th>
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</table>

### Problem Solving

<table>
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</tr>
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<td>Strategies</td>
<td>Lists Strategies, Procedures that might be used for solving the problem</td>
<td>Uses a single Strategies, Procedures appropriate to finding a solution</td>
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<tr>
<td>Evaluation</td>
<td>Identifies some Contexts, Feasibility issues, Confounds / sources of error that relate to the problem</td>
<td>Explains Contexts, Feasibility issues, Confounds / sources of error when addressing the problem</td>
<td>Assesses Contexts, Feasibility issues, Confounds / sources of error when solving the problem</td>
<td>Evaluates Contexts, Feasibility issues, Confounds / sources of error when solving the problem</td>
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</tbody>
</table>

Note: the rubric criteria

**Finalize**
Rubrics generated are listed here

Rubrics are searchable

Pilot project feedback here

Learning Outcomes Project

Building Assessment Scaffolds for Intellectual Skills

Start Here  Feedback  View List  Search

Your rubric has been saved! Download your rubric in CSV format.

Assignment: "research design"

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Define problem:
- Describes the Purpose as related to research design
- Explains the Purpose as related to research design
- Analyzes Purpose, contextually appropriate to research design
- Evaluates the contextually diverse nature of the Purpose applied to research design

Strategies:
- Lists Strategies, Procedures that might be used for solving the problem
- Uses a single Strategies, Procedures appropriate to finding a solution
- Incorporates multiple Strategies, Procedures to find a solution
- Adapts Strategies, Procedures to allow for complexities when finding a solution

Solution / hypothesis:
- Presents simplistic Design, Hypothesis that partially address the problem
- Presents satisfactory Design, Hypothesis addressing the problem
- Presents coherent Design, Hypothesis tailored to the problem
- Presents elegant Design, Hypothesis comprehensively addressing the problem

Evaluation:
- Identifies some Contexts, Feasibility issues, Confounds / sources of error that relate to the problem
- Explains Contexts, Feasibility issues, Confounds / sources of error when addressing the problem
- Assesses Contexts, Feasibility issues, Confounds / sources of error when solving the problem
- Evaluates Contexts, Feasibility issues, Confounds / sources of error when solving the problem
Cost and effort of assessing

Evaluating coursework with generic rubrics becomes more difficult in upper-year courses, as content expertise is required.

Standardized testing is more time consuming and expensive.

Cost per Completed Consenting Sample

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost per Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLA+</td>
<td>$45</td>
</tr>
<tr>
<td>CAT</td>
<td>$25</td>
</tr>
<tr>
<td>VALUE Marking</td>
<td>$15</td>
</tr>
</tbody>
</table>
Measuring CT

Standardized tests
• Allow for external comparison, “turnkey”
• Often have motivational problems or self-response bias
• Small gains (over 1 year) can be hidden

Embedded assessment
• Often causes instructors to think about CT in courses
• Alignment issues: course assignments may not explicitly require CT
Today’s experts

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