Data Driven, Iterative Refinement of Program-Level Student Learning Outcomes

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Teaching Excellence & Educational Innovation
Today’s Roadmap

1. **Why is data-informed teaching valuable?**

2. **How does it translate to the program-level?**

3. **What are effective, efficient practices?**
   
a) **Learning objectives**
   b) **Curriculum mapping**
   c) **Identifying and aligning data sources**
   d) **Collecting and analyzing data**
   e) **Turning data into action plans**
Mantras:

1. There is always room to improve.
2. Perfection is NOT the goal.
3. Progressive, iterative refinement is a sustainable and practical goal.
4. Start small, focus, and build over time.
Disclaimers:

1. I’ve seen some of your assessment plans/reports.

2. They inspired examples I’ll use today. (note liberal creative license and mash ups).

3. I’m not here to criticize or evaluate you.

4. Slides may differ from handout, slightly.
Today’s Roadmap

1. Why is data-informed teaching valuable?

2. How does it translate to the program-level?

3. What are effective, efficient practices?
What does data-driven teaching look like? What opportunities does it create?
Data can help drive positive feedback loops

Set Goals & Plan

Identify relevant data

Motivation

Prior knowledge and experience

Task constraints

Resources & opportunities

Gather & analyze data

Evaluate & Adapt

Apply Strategies & Monitor

Draw conclusions

(Butler, 1997; Pintrich, 2000; Winne & Hadwin, 1998)
Questions guiding data-driven teaching…

1. What do you wish you knew about student learning?

2. What would you change, if you had the data?
Teaching as Research

Discovering what works for student learning

At the intersection of faculty research, teaching, and service, the Eberly Center supports Teaching as Research. We help faculty answer compelling research questions regarding which teaching strategies are more effective at promoting learning, increasing engagement, and enhancing the learning environment. Our services provide the tools and expertise to help instructors develop research questions and study designs, identify valid and reliable data sources, analyze and interpret educational data, and present and publish research results. Read more about our research processes and findings in this site.
Case study: Do inquiry-based labs enhance application skills?

Sarah Christian: Civil & Environmental Engineering
Is it feasible to build this garage from the masonry units provided?
Case study: Do inquiry-based labs enhance application skills?

Inquiry-Based Lab Content

“Cookbook” Lab Content
Questions guiding data-driven teaching…

1. What do you wish you knew about student learning?

2. What would you change, if you had the data?

Note: These questions provide meaning beyond checking boxes.
The value proposition of data-driven teaching includes:

- Improved student learning
- Progressive pedagogical refinement
- Research, publication, & presentation
- Development of new tools or methods
- Bragging rights

(And, yeah, reporting to accreditation agencies)
Effective assessment practices illustrated by this case study include…

1. Focus meaningfully, where do students struggle?
2. Start small and iterate.
3. Leverage **direct, embedded** assessments.
4. Alignment is critical.
Today’s Roadmap

1. Why is data-informed teaching valuable?
2. How does it translate to the program-level?
3. What are effective, efficient practices?
What’s the same at the program-level?

1. The guiding questions are the same.
   - What do you wish you knew about student learning?
   - What would you change, if you had the data?

2. The steps of the cyclical process.
Program-level assessment is a cyclical, iterative process.

1. Identify Learning Objectives & Questions
2. Map Curriculum
3. Identify & Align Data Sources
4. Collect & Analyze Data
5. Implement Data-Informed Action Plan

Program-level assessment is a cyclical, iterative process.
What’s different at the program-level? The scale of...

- inquiry is across courses.
- faculty “skin in the game”.
- Leadership?
- Are the right people at the table?
- Resources and effort (time)?
- Access (e.g., to students, faculty, alumni)?
- Sustainability?
Today’s Roadmap

1. Why is data-informed teaching valuable?
2. How does it translate to the program-level?

3. What are effective, efficient practices?
   a) Learning objectives
   b) Curriculum mapping
   c) Identifying and aligning data sources
   d) Collecting and analyzing data
   e) Turning data into action plans
Program-level assessment is a cyclical, iterative process

1. MAP CURRICULUM
2. IDENTIFY & ALIGN DATA SOURCES
3. IDENTIFY LEARNING OBJECTIVES & QUESTIONS
4. COLLECT & ANALYZE DATA
5. IMPLEMENT DATA-INFORMED ACTION PLAN
Why bother with learning objectives? What’s the added value?

1. Establish/reconnect with a shared vision.
   • What are we doing?
   • What do we value most?
   • What threads should connect courses?

2. Why are we doing it that way?

3. Is it the best way for our students?
Effective learning objectives are...

**Student-centered**
- *What will your students learn?*

**Action-oriented**
- *What will students be able to do with the skills or knowledge that they acquire?*

**Measureable**
- *How will I determine whether the student has mastered the learning objective?*
- *It should be easy to identify how you would observe a student’s demonstration of mastery.*

Simon & Taylor (2009)
Activity: What’s effective about these learning objectives? How could they be improved?

After graduating, students should be able to:

1. Demonstrate knowledge of mathematics, science, and engineering practice required for problem solving.

2. Appreciate how the history of Western thought influences current debates in the philosophy of religion.

3. Understand the applicability of the modern technology necessary for professional practice.

**HINT:** Learning Objectives should be...

1. Student-Centered
2. Action-Oriented
3. Measurable
Examples of revised learning objectives re: problem solving…

*Original*: Demonstrate knowledge of mathematics required for problem solving.

*Revised*: Students should be able to:

a) Recognize and recall major linear algebraic definitions and theorems.

b) Compute and geometrically interpret the dot and cross products of vectors.

c) Solve problems using matrix techniques and algorithms.
Activity: Which of the following is the most effective learning objective? Why?

Students should be able to:

A. Successfully complete the manufacturer’s training requirements.

B. When given a vehicle with a mechanical concern,
   • develop a logical action plan,
   • follow a manufacturer approved diagnostic procedure,
   • isolate the cause of the concern,
   • recommend an appropriate repair, and
   • verbally describe how to verify the repair.

C. Develop an action plan to diagnose a vehicle fault, including information obtained from the manufacturer’s diagnostic procedure.
Case Study: What are students learning?

1. MAP CURRICULUM
2. IDENTIFY & ALIGN DATA SOURCES
3. IMPLEMENT DATA-INFORMED ACTION PLAN
4. COLLECT & ANALYZE DATA
5. IDENTIFY LEARNING OBJECTIVES & QUESTIONS
Case study: Program-level objective

Use foundational knowledge for advanced work in the discipline.
Students should be able to critically evaluate data.

When presented with a scientific study, students should be able to determine whether appropriate:

1. methods were used,

2. controls were used,

3. statistical techniques were used,

4. analysis and interpretation occurred, and

5. conclusions were drawn.
Case Study: What are students learning?

1. Identify Learning Objectives & Questions
2. Map Curriculum
3. Identify & Align Data Sources
4. Collect & Analyze Data
5. Implement Data-Informed Action Plan

Identify Data-Informed Action Plan
## Curriculum mapping: Where are the opportunities for students to learn this?

**EXAMPLE: INDIVIDUAL FACULTY CURRICULUM MAP**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROGRAM OUTCOME</strong></td>
<td><strong>SPECIFIC SKILL</strong></td>
<td><strong>COURSE MAPPING INSTRUCTIONS</strong></td>
<td><strong>Course #</strong></td>
</tr>
</tbody>
</table>
| Use foundational knowledge from the natural sciences and mathematics for advanced work in the discipline. | Critically Evaluate Data  
Subskills: Determine whether appropriate:  
1. methods were used  
2. controls were used  
3. statistical techniques were used  
4. analysis and interpretation occurred  
5. conclusions were drawn | In this row, please review the subskills in Column B and list the specific subskill number(s) that you teach AND assess in your course. | All |
| | | In this row, please insert "I" (introductory), "A" (advanced), or "M" (mastery) to indicate at what level students should be able to perform this skill(s) by the end of the course. | A |
| | | Insert assessments from your course that could be used to assess student performance on the subskills you identified. | - Project: critically analyze experimental paper(s) |

**I, A, M Designations re: knowledge or skill**

I = Introductory (e.g., recall or explain concepts)  
A = Advanced (e.g., apply a procedure or analyze how parts compare/contrast)  
M = Mastery (e.g., independently know how and when to apply skills)
Curriculum mapping: Where are the opportunities for students to learn this?

**EXAMPLE: AGGREGATED CURRICULUM MAP**

<table>
<thead>
<tr>
<th>Specific Skill</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically Evaluate Data</td>
<td>All but #3</td>
<td>All but #3</td>
<td>Not Applicable</td>
<td>All but #3</td>
<td>All but #3</td>
<td>All but #3</td>
<td>NA</td>
<td>All</td>
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<td>Subskills: Determine whether appropriate:</td>
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<tr>
<td>1. methods were used</td>
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<td>I</td>
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<td>I</td>
<td>A</td>
<td>A</td>
<td>NA</td>
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<td>2. controls were used</td>
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<tr>
<td>3. statistical techniques were used</td>
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<td>4. analysis and interpretation occurred</td>
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<td>5. conclusions were drawn</td>
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<tr>
<td>- Write specific questions about research papers</td>
<td>- Exam questions</td>
<td>NA</td>
<td>- Exam questions - In-class presentations</td>
<td>- Homework - In-class exams</td>
<td>- Lab reports - Paper discussion assignments - Final exam</td>
<td>NA</td>
<td>- Project: critically analyze experimental paper(s)</td>
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</tbody>
</table>
Activity: Curriculum mapping. Where are the opportunities for students to learn this?

Is there value to this exercise? Or, is it “busy work”? What did the department learn?

<table>
<thead>
<tr>
<th>CRITICALLY EVALUATE DATA Determine whether appropriate:</th>
<th>Total I</th>
<th>Total A</th>
<th>Total M</th>
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<tbody>
<tr>
<td>1. methods were used</td>
<td>6</td>
<td>8</td>
<td>3</td>
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<tr>
<td>2. controls were used</td>
<td>6</td>
<td>7</td>
<td>3</td>
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<tr>
<td>3. statistical techniques were used</td>
<td>3</td>
<td>3</td>
<td>2</td>
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<tr>
<td>4. analysis and interpretation occurred</td>
<td>6</td>
<td>8</td>
<td>3</td>
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<tr>
<td>5. conclusions were drawn</td>
<td>6</td>
<td>8</td>
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</tbody>
</table>
Program-level assessment is a cyclical, iterative process

1. IDENTIFY LEARNING OBJECTIVES & QUESTIONS
2. MAP CURRICULUM
3. IDENTIFY & ALIGN DATA SOURCES
4. COLLECT & ANALYZE DATA
5. IMPLEMENT DATA-INFORMED ACTION PLAN
Case study: Identification of **embedded data sources** (direct measures) can occur during curriculum mapping.

**EXAMPLE: AGGREGATED CURRICULUM MAP**

Program Outcome: Use foundational knowledge from _____________ for advanced work in the discipline.

<table>
<thead>
<tr>
<th>Specific Skill</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<th>F</th>
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<td>Critically Evaluate Data</td>
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<td>2. controls were used</td>
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<td>5. conclusions were drawn</td>
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<th>All but #3</th>
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<tr>
<td>- Write specific</td>
<td>- Exam</td>
<td>- Exam</td>
<td>- Exam</td>
<td>- Homework</td>
<td>- Lab</td>
<td>- Project:</td>
<td>- Write</td>
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<td>final exam</td>
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</tbody>
</table>
What should you ask about any data source?

1. How reliable is it?
   degree to which the data is stable and consistent

2. How valid is it?
   how well the data measures what it is intended to measure
What should you ask about any data source?

3. Is it a direct or indirect measure?

*Direct:*

observation of the actual performance or behavior, OR
self-report of a belief

*Indirect:*

someone’s perception or rating of the targeted performance or behavior
Research on student self-reports and direct and indirect measures

1. Direct measures of learning taken as more valid (less biased) than indirect measures

2. Self-reports and direct measures of learning follow different patterns

3. Self-reports can be appropriate when you are measuring student perceptions or beliefs per se
What should you ask about any data source?

4. Is it a quantitative or qualitative measure?

- Either can be direct or indirect.
- Neither is “better”.
- Each provides insight.
- Can be a powerful, complementary combo.
What should you ask about any data source?

Summary

Valid?

Reliable?

Direct or Indirect?

Quantitative or Qualitative?
Activity: Discuss pros & cons of data sources

<table>
<thead>
<tr>
<th>Quality Measure? (Validity &amp; Reliability)</th>
<th>Difficult to Collect?</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Easy</td>
</tr>
<tr>
<td>Low</td>
<td>Hard</td>
</tr>
</tbody>
</table>

- Direct measure: Student knowledge (pre/post test)
- Indirect measure: Student self-report re: learning or preparedness (post survey)
Activity: Which quadrant?
Capstone, group project artifact

Quality Measure?
(Validity & Reliability)

High

Low

Difficult to Collect?

Hard

Easy

1

2

3

4
Activity: Which quadrant?
Student focus groups re: experiences completing a capstone project/assignment

<table>
<thead>
<tr>
<th>Difficult to Collect?</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Easy</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Activity: Which quadrant?
Final course grades

Quality Measure? (Validity & Reliability)

High
Low

Difficult to Collect?
Hard
Easy

1
2
3
4
Activity: Which quadrant?
Evaluation of student written work using a portion of a rubric developed by the instructors.
Activity: Which quadrant?
Evolution of student language used in weekly written reflections (assignments)

<table>
<thead>
<tr>
<th>High Quality Measure? (Validity &amp; Reliability)</th>
<th>Difficult to Collect?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>Low</td>
</tr>
<tr>
<td>Hard</td>
<td>High</td>
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</tbody>
</table>

1  2  3  4
Activity: Which quadrant?
Scores on authentic task or case study analysis (locally developed)

Difficult to Collect?

<table>
<thead>
<tr>
<th>Quality Measure? (Validity &amp; Reliability)</th>
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<tbody>
<tr>
<td>Low</td>
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<tr>
<td>High</td>
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<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>3</td>
<td>4</td>
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</table>
Case Study: What are pros and cons of pre-tests? How to mitigate the cons?

Program-level inquiry aspires to measure across courses.

Courses early in sequence vs. late can function as pre- and post-tests, respectively.
Case study: Sometimes, the direct, embedded assessments in courses are not aligned with learning objectives or missing. You can revise or create them.

Which truth table corresponds to the logic gate shown?

Options:

A

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
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<tr>
<td>0</td>
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</tbody>
</table>

B

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>1</td>
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C

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
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<tr>
<td>1</td>
<td>1</td>
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<tr>
<td>0</td>
<td>1</td>
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<td>0</td>
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D

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
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</tbody>
</table>
Case study: Sometimes, the direct, embedded assessments in courses are not aligned with learning objectives or missing. You can revise or create them.

Which pair of plots of voltage vs time, $V(t)$, and voltage magnitude vs frequency, $|V(f)|$, could come from the same signal?

(Pay careful attention to the units on the axes.)
How could you mitigate the cons of pre-tests within courses?

- Carefully frame pre-tests as a means to tailor instruction to student needs (and transparently follow up/through).
- Leverage pre-tests as a learning opportunity. How could you use the as the basis of a classroom activity?
Activity: Which is a best data source?

Gen ed goal: Critical thinking

Learning objective: Using illustrative examples from plays, analyze the effect of modern psychology on the development of dominant trends in 20th century theatre (e.g., realism, naturalism, expressionism, surrealism, and absurdism).

1. Concept map drawn and annotated by students.

2. Survey re: student preparedness for applying conceptual knowledge to professional roles in contemporary theatre productions.
Activity: Which is a best data source?
Gen ed goal: Information literacy

Learning objective: Given a controversy, argue for or against a position, supporting arguments with relevant and appropriate sources.

1. Multi-paragraph essay, including citations and an annotated bibliography.

Activity: Which is a best data source?  
Gen ed goal: Communication

**Learning objective:** Students will display professional behaviors congruent with ethical standards of the profession.

1. Reports from supervisors in experiential field placements, based on detailed behavioral rubrics.

2. A memo (1-2 pages) to a supervisor regarding an unethical situation in a professional context, including recommendations for how to address/prevent such situations.
Program-level assessment is a cyclical, iterative process

1. MAP CURRICULUM
2. IDENTIFY & ALIGN DATA SOURCES
3. IMPLEMENT DATA-INFORMED ACTION PLAN
4. COLLECT & ANALYZE DATA
5. IDENTIFY LEARNING OBJECTIVES & QUESTIONS
ALIGN the components of your courses and program.

Activity: Practice Alignment Checking

Is the example below a demo of course-level alignment? Why or why not?

Learning Objective
Apply the principles of critical thinking in the development of technical documents and reports.

Assessment: Midterm Exam Question
Identify and describe the five-step process of new product development.

Instructional Strategy
Students will view a documentary entitled “Steve Jobs: The Man in the Machine”.
Activity: Practice Aligning to Gen Ed

To what extent is any part of the example below aligned with CCAC general education goals?

Learning Objective
Apply the principles of critical thinking in the development of technical documents and reports.

Assessment: Midterm Exam Question
Identify and describe the five-step process of new product development.

Instructional Strategy
Students will view a documentary entitled “Steve Jobs: The Man in the Machine”.
Case Study: What are students learning?

1. Identify Learning Objectives & Questions
2. Map Curriculum
3. Identify & Align Data Sources
4. Collect & Analyze Data
5. Implement Data-Informed Action Plan
Case Study: What are students learning?

1. IDENTIFY LEARNING OBJECTIVES & QUESTIONS
2. MAP CURRICULUM
3. IDENTIFY & ALIGN DATA SOURCES
4. COLLECT & ANALYZE DATA
5. IMPLEMENT DATA-INFORMED ACTION PLAN
Case Study: What’s the essence of an action plan resulting from assessment data?

Imagine two sets of embedded exam questions, average scores were 45% and 75%.

What should be tweaked:

• Learning objectives?
• Alignment?
• Assessments and rubrics?
• Practice and feedback?

Where in the curriculum map? ...in a course?
50 years of education research provides a lens for how to think about an action plan.

During and between class sessions…

frequent, low stakes, practice

AND

targeted feedback

enhance learning.

Ambrose et al. (2010)
Curriculum mapping: Where are the opportunities for students to practice and get feedback?

Go back to the curriculum map....
Concluding thought on data-driven teaching:

“Assessment done properly should begin conversations about performance, not end them.” (Wiggins, 1993)