Assessing Challenge-Based Instruction in Biomedical Engineering

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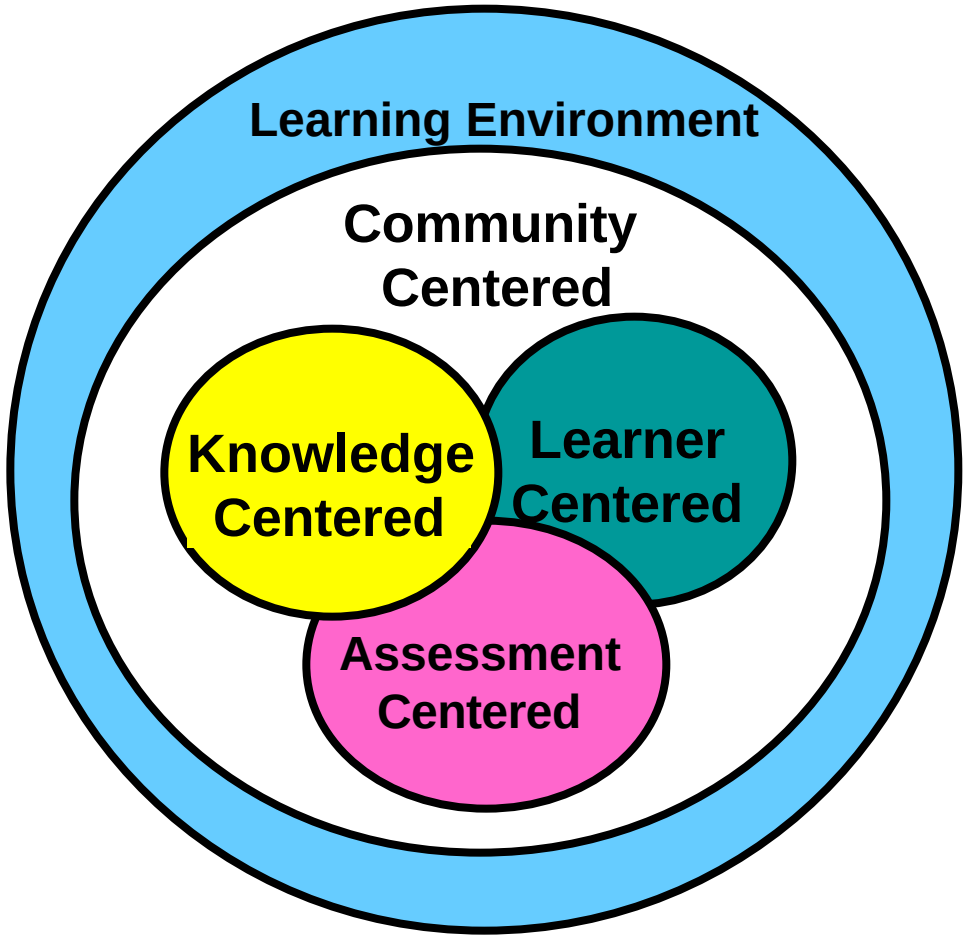
Overview of VaNTH

- Engineering Research Center funded by National Science Foundation for up to 8 years (September, 1999 -)
- Four Institutions: Vanderbilt, Northwestern, University of Texas at Austin, Harvard-MIT Division of Health Sciences and Technology
- A focus of VaNTH is to:
  - Develop educational materials
  - Study learning of engineering students and teaching by bioengineering faculty to determine best practices in engineering education.
- Organized into research and development “thrusts”:
  - Domain Thrust
  - Learning Science Thrust
  - Learning Technology Thrust
  - Assessment and Evaluation Thrust

Pedagogical Foundation of VaNTH

- **LC: Build on prior knowledge**
- **KC: Integrated understanding, applications**
- **AC: On-going assessment, monitor understanding, encourage reflection, remedy misconceptions**
- **CC: Promote interaction and collaboration, take advantage of community to build on each other's knowledge**
- **Create Challenges**
  - **Open-ended**
  - **Real life scenarios**
  - **Embed concepts as well as engineering skills**



John Bransford, et al. (1999) How People Learn. National Academy Press.

Focus for Today's Presentation

1. Biotechnology Domain
2. Northwestern
    1. HPL-materials developed for Bioprocess Technology course
    2. Challenges created
    3. Study conducted to capture potential benefits of HPL approach
        1. HPL course: BME395, 11 students
        2. Comparison non-HPL course, 11 students
3. Overview of Assessment Plan
    1. Assessment questions
    2. Scoring rubrics
    3. Coding and data analysis
4. Present Results
5. Discussion
    1. Cross-Institutional Collaboration

Development of Assessment

- Assessment aligned with learning goals
  - Capture content understanding
    - Biotechnology concepts
  - Open-ended problem solving ability
    - Aspects of adaptive expertise
- Matched to curricula materials
  - Assessment similar to what we ask students to do as part of the class
    - Challenge-based
    - Support goals of course
    - aka ‘assessment-centered’

Assessment
Parts 'A and C'

- Part A: Open-Ended Challenge
  -Attempt to capture general, 'adaptable' problem solving skills

-ability to design a plan
-ability to identify necessary resources
-considers multiple solution paths
-identifies technical, business, ethical, safety, etc issues.

- Part C: Kinetic Model
  -Measure ability to propose an appropriate kinetic model of system
  -Understanding of limitations, constraints, assumptions, etc.

develop understanding of:
-relationship of product formation to model
-relationship of biomass growth to model
-relationship of substrate utilization to model
-limitations/assumptions in model development
-variables to be considered in model
-model parameters

Procedure

- Week 2 -Administer assessment Parts A, B, and C
  -Take-home, 90-min, open book
- Week 7 -Administer Part C as a homework assignment
  -2nd implementation to correct for time complaints
- Week 11 -Midterm Exam II to include Parts A and C

Development of Rubric

1. Create categories to represent learning goals
    1. Make scale that seems appropriate
2. Read sample of student/expert responses
    1. Refine categories to capture what is present in the data
3. Consult with team
    1. Do categories/scale make sense?
4. Apply rubric to sample of data
    1. Compare scores among raters, discuss areas of disagreement, final revisions

All Categories
Part A

1. A. Student identifies and discusses biological factors involved in the design
2. B. Student identifies and discusses business and economic factors involved in the design.
3. C. Student identifies and discusses safety and environmental factors involved in the design.
4. D. Student devises a work plan to solve problem.
5. E. Student identifies and discusses necessary resources to carry out plan.
6. F. Student describes or considers multiple solution options.
7. G. Student identifies and discusses ethical issues relating to the design.
8. H. The overall response provides an appropriate integration of all the issues that should be considered in the design.

Sample Category Rubric for Part A

- **Category D: Student devises a work plan to solve problem**

5 provides a sophisticated discussion of all critical tasks and actions necessary to solve problem

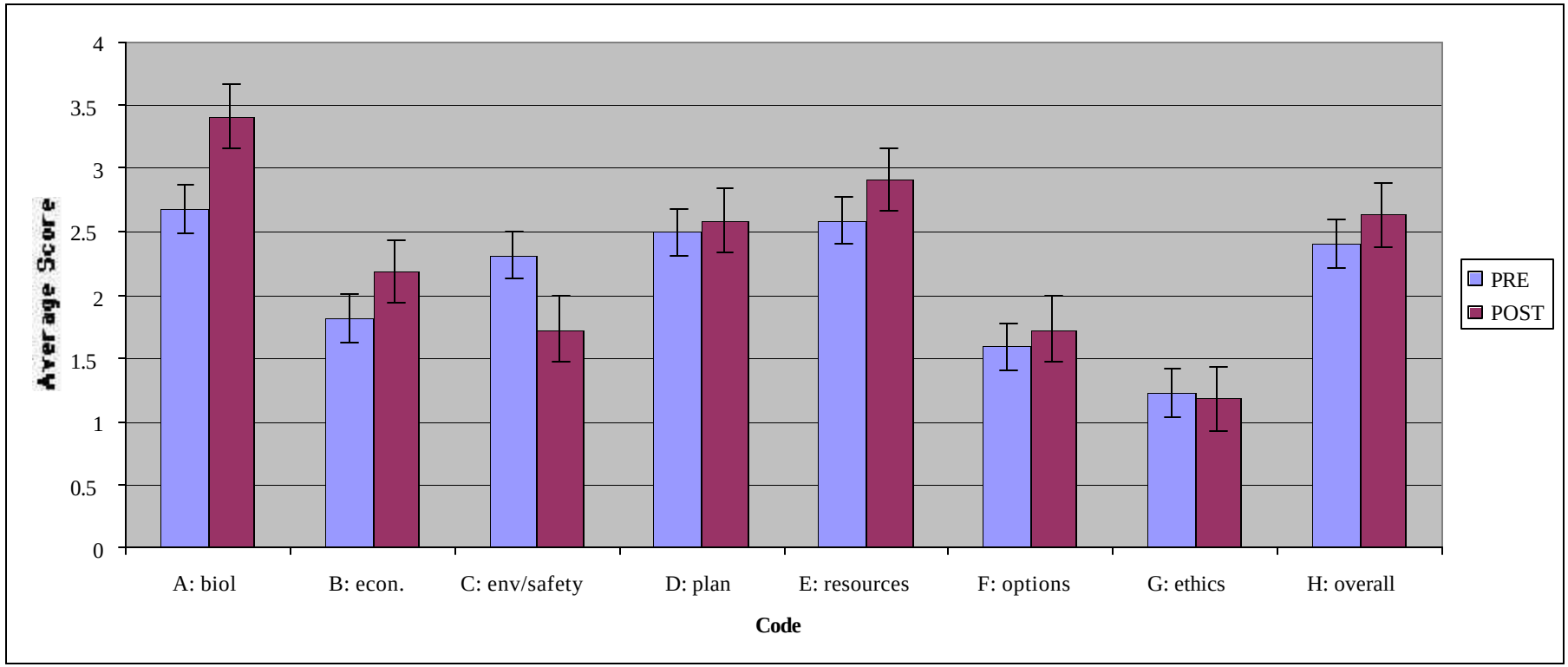
4 provides a good discussion of most of the critical tasks and actions necessary to solve problem

3 provides an average discussion of some of the critical tasks and actions to solve problem

2 provides a limited discussion of few of the critical tasks and actions to solve problem

1 fails to identify any of the critical tasks necessary to solve problem to solve problem

Results Part A
HPL Course



Category A: t(21) = 3.167, p < .01
Category C: t(21) = -2.63, p = .015
Rater Correlation A/D = 0.725

Discussion of Results Part A

1. Significant increase in post-test performance in only one category. Why?
    1. Class and/or modules need to be refined to better address these learning outcomes
    2. Wording of the assessment question
        1. Prompts influence how student responds
        2. Issue regarding what students *can* do vs. what they *did* do
    3. Innovative assessment departs from the norm--different expectations
    4. Form of administration (pretest given as homework as opposed to post-test given as a take home exam)
    5. Time constraint for the students

All Categories
Part C

A. Student describes or considers different limitations that cells may encounter during growth/protein production

B. Student identifies or discusses the variables to be considered in the model.

C. Student relates the product formation to the model.

D. Student relates the biomass growth to the model.

E. Student relates the substrate utilization to the model.

F. Student identifies and discusses the assumptions to be considered in the model development by making use of background information.

G. Student proposes a strategy to find the model parameters.

H. The overall response provides an appropriate integration of all the issues that should be considered in microbial kinetic modeling.

Sample Category Rubric for Part C

- **C. Student relates the product formation to the model.**

5 accurately connects the rate expression for product formation to the overall model.

4 accurately writes the rate expression for product formation

3 identifies and tries to write the rate expression for product formation.

2 identifies what to write in the rate expression for product formation.

1 fails to write the rate expression for product formation.

Definition of Scale for Category 'C'

Solution

Score

$$\frac{dP}{dt} = r_{fp} = (1/Y_{p/x})\, m\, X$$ **C.5**

$$r_{fP} = a\, r_{fx}$$

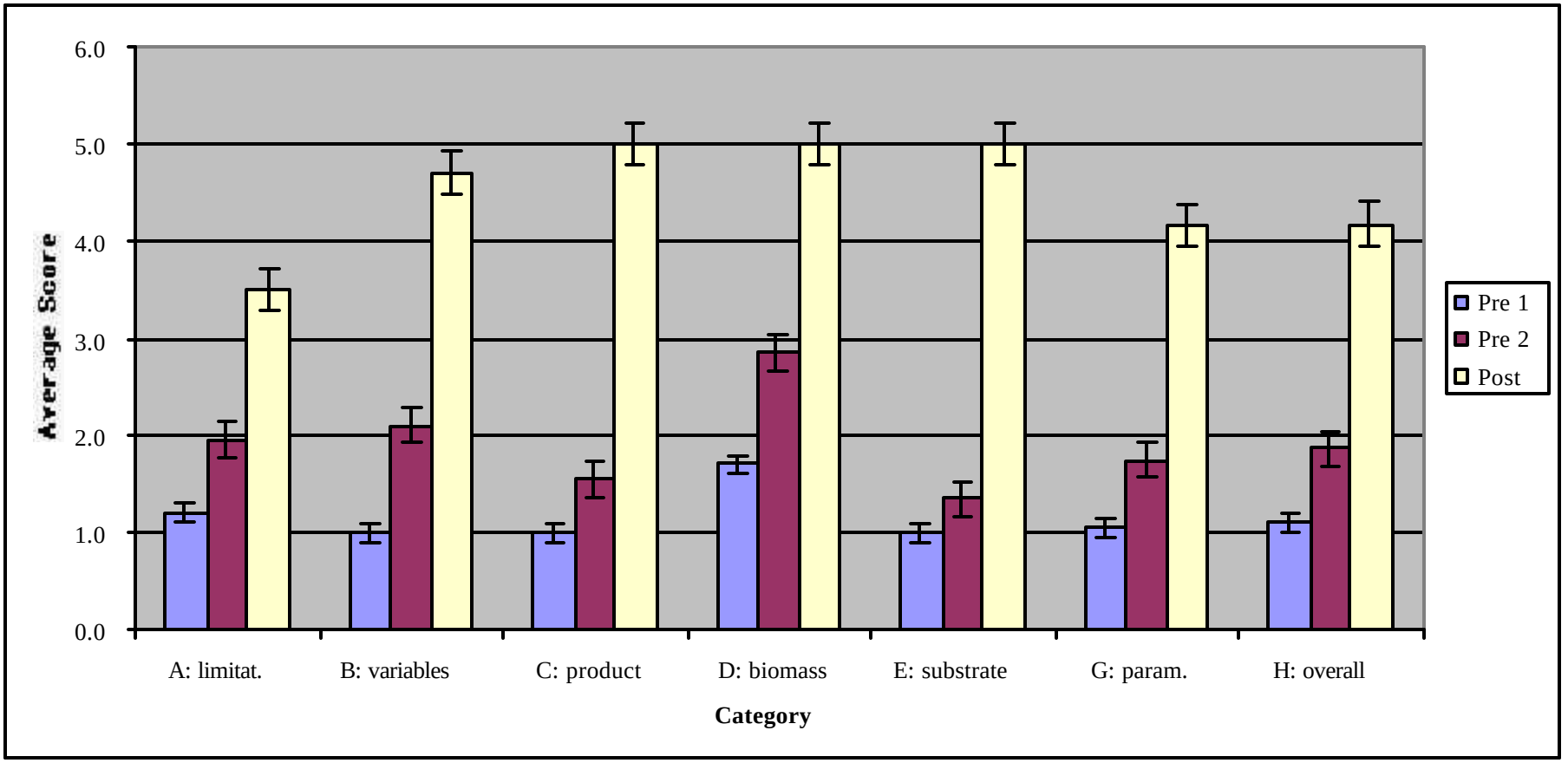
Since, the protein (product) is a primary metabolite (assumption 2), βX term vanishes. Thus, the rate expression for product simplifies to **C.4**

$$r_{fP} = a\, r_{fx} + b\, X$$ **C.3**

Product: should contain a growth associated and a non-growth associated terms **C.2**

Student fails to write the rate expression for product formation. **C.1**

Results Part C
HPL Course



All Categories significant at $p < .01$ level
Rater Correlation: A/G = .92, D/G = .58

Discussion of Results Part C

- Result indicate course successful in supporting content understanding
- Results display strengths in specific categories of understanding--focused analysis
  - Capture gains/weaknesses on specific concepts
- Integration of mathematical and scientific principles
  - Applying mathematical analysis to appropriate model
  - Suggests synthesis and application of interdisciplinary ideas
- Previous versions of course indicated:
  - Students understood rate expression
  - Students had difficulty in creating model---our data indicates different results here

Noteworthy Points about our Assessment Work

- Have shown it is possible to develop assessments to capture open-ended problem solving skills and content understanding
- Qualitative data CAN be analyzed in a rigorous way and provide valuable information
- 'Assessment process' has helped faculty to develop a better understanding of how to design assessments to address valued learning outcomes
  - HPL lingo: more learner-centered and assessment-centered

Caveats

- Limitations
  - Lack of control
    - Difficult to isolate effects---therefore difficult to identify cause-effect relationship
  - Requires commitment from all partners to make happen
    - Faculty
    - LS/AE folks
    - Students
  - Lack of immediate feedback after Pretest
  - Need fine adjustments to avoid burden on students and faculty
    - time constraints
    - Trade off (another homework question versus assessment question)