The Components of Reform Teaching

Mojgan Matloob & Dean Zollman

Kansas State University

Collaborative Partners
University of Alabama
San Diego State University

Supported by National Science Foundation Grant ESI-055494

1

Reform Teaching and background information

- Deficiencies in science teaching at K-12 and higher education levels led to creation of new standards
- Standards are criteria to judge if certain actions serves a vision of scientifically literate society

  - Project 2061(1985):Benchmarks for Science Literacy for next generation
  - National Science Education Standards (NSES) (1996)

2

Concerns which discouraged students of pursuing science major

- Passive students roles
- Focus on algorithm and problem solving
- Lack of relevance
- Emphasis on competition
- Science being presented as a set of facts
- Assessment as a tool for measuring the effort, demonstration of recall and gaining a body of knowledge

3

Components of Reform

- Based on National Science Standards
- Student-centered, i.e. active student roles
- Inquiry-based pedagogy and laboratories
- Builds on students' prior knowledge
- Incorporates interdisciplinary learning and connection between scientific ideas
- Multiple modes of assessment
- Promote collaborative and group working
- Provide social, historical and philosophical context

4

NOVA Program (NASA Opportunities for Visionary Academics)

NOVA was created to disseminate a national framework for enhancing science, mathematics and technology literacy for pre-service teachers in the 21st century

- 106 participating institutions nationwide
- 23 national workshops
- More than 150 courses developed or modified to incorporate inquiry-based approach.

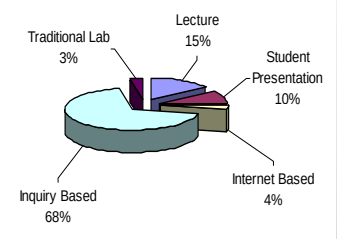
5

NOVA Professional Development Model

6

Reform Undergraduate Course

- Pedagogy in Study Reform Courses – Weekly Time Use



7

The National Study of Education in Undergraduate Science (NSEUS)

- Investigating undergraduate reform science course vs. non-reformed course in 103 universities impacted by NASA/NOVA

8

NSEUS-Research Questions

1) What are the essential characteristics of an entry level reformed undergraduate science course?
2) How do reform science course characteristics differ from traditional courses?
3) How do course characteristics relate to undergraduate students short-term learning outcomes?
4) How do characteristics differ between courses with varying degrees of reform?
5) How do varying degrees of reform relate to undergraduate students short-term learning outcomes?
6) How do reform and traditional courses differ in their long-term impacts on K-6 teachers in their own science classrooms?

9

Types of Evaluations and Measurements

- Non-content surveys:
  - Nature of Science
  - Attitudes about teaching Science
- Classroom Observations
- Content Knowledge

10

Instrumentation (Partial list)

- Science Teaching Efficacy and Beliefs Instrument (STEBI, A & B)[1]
  Teachers' action is representative of their believes. Efficacious teachers are more likely to use open-ended, student centered strategies[2]
- The Reformed Teaching Observation Protocol (RTOP)[3]
  Developed on the base of National Standards that assess to what degree course is reformed

1-(Riggs & Enochs, 1990), 2-(Ashton & Webb 1980), 3- Sawada, Turley, Falconer, Benford & Bloom, 2002)

11

Traditional or indirect content assessment

- The common strategy is through competitive, timed, written quizzes
- The problems are well-defined and have one true answer
- The focus is on material and testing particular body of knowledge has been gained
- The focus is not on personal construction
- Traditional assessment is like single snapshot of students learning
- Infer indirectly that student can apply knowledge in real life

12

Authentic or direct content assessments

- Long-range projects, exhibits, and performances that are linked to the curriculum with focus on process and rationale
- Using real world contexts
- Viewed as "direct", since tasks are designed to incorporate the contexts, problems, and solution strategies that students would use in real life
- No single answer, ill structured to prepare students for the ambiguities of the real life
- It's like video taping of students' learning

13

Authentic vs. traditional assessment

- Authentic
- Issue with subjectivity
- Shine on validity
- Reliability issues
- Costly and time consuming
- Not accepted in society yet
- Statistical reports
- Needs other student skills
- Needs technical support
- Convince students

- Traditional
- Issue with validity
- Good for reliability
- Statistical report
- Many aspects remained unevaluated
- Coding system

14

Tools to assess the quality of inquiry

- Mechanistic reasoning (Describing Target Phenomena, Set-up Conditions, Identifying Entities, Identifying Activities)[1]
- Meaningful Understanding[2]
- Structural, Behavior and Functional framework (SBF)[3]
- Dynamic Transfer
- Concept Maps[4]
- Structured Interview

1- Russ & Hutchison (2006), 2-Neiswandt & Bellemo 2007, 3-Hmleo Silver et. Al (2003), 4-Edmondson (2000)

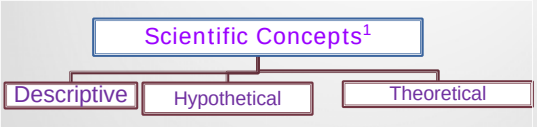
15

Question of this study

- To compare content knowledge across disciplines
- How students use concepts they have learned and what are their reasoning patterns?
- Conceptual tests of understanding (FCI)?

16

Meaningful Understanding



The hypothesis to be investigated is that Concept construction proceeds from descriptive concepts toward advanced theoretical concepts depending in part on intellectual development

[1]Lawson et. al (2000)

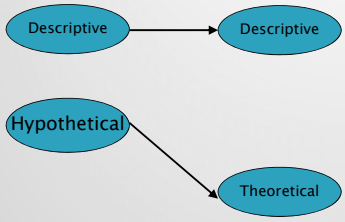
17

Meaningful understanding and scientific concepts

- Descriptive concepts: Concepts that can be inferred or observed with direct senses e.g. magnets, organisms, food chain
- Hypothetical concepts: the concepts that cannot be observed directly but indirectly or if the observational time period were extended e.g. magnetic fields or fossils
- Theoretical concepts: The concepts that can't be observed and the meanings come from the theories which ideas originate e.g. atoms and genes

18

Assessing meaningful understanding



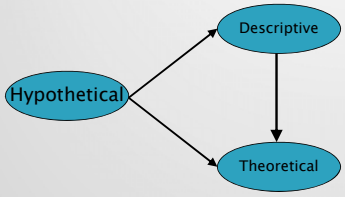
One-Concept-Level link

Cross-Concept-Level link

Neiswandt & Bellemo 2007

19

Assessing meaningful Understanding cont.



Multi-Concept-Level links

20

Six step procedure developed in Meaningful Understanding study

1. Dividing students' answers into segments reflecting individual idea
2. Highlighting the scientific term of each segment
3. Classifying the scientific terms
4. Comparing with exemplary answers and noting the missing parts
5. Linking the concepts
6. Highlighting patterns across the questions

21

Meaningful understanding method and shortages

- Criteria of categorizing is for concepts in biology (hypothetical concepts)
- Lack of systematic coding to differentiate recall and understanding
- Compare and contrast, size and proportionality is not included
- Subjectivity in assessing of Procedural, Schematic and Strategically knowledge
- What to say when students use theoretical and hypothetical concept in a wrong context
- How to distinguish between familiar concepts and new concepts that student may construct
- P-prims and students' reasoning is not included

22

AEM[1] Survey Questions Alabama

- A passenger is travelling in a Boeing 747 with a constant speed and through a ball straight up.

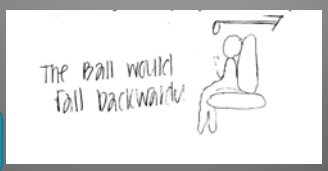
  Describe the motion of the ball as seen by the passenger who threw it (Include illustrative drawing).

Suppose you are sitting next to passenger. Explain why the ball moved as it did.

1-AeroSpace and Engineering Mechanics

23

Student reasoning cont.



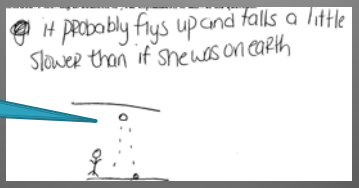
Attaching frame of reference to fixed objects

Moving frames

Velocity/ Over shadowing gravity

24

Students' reasoning cont.



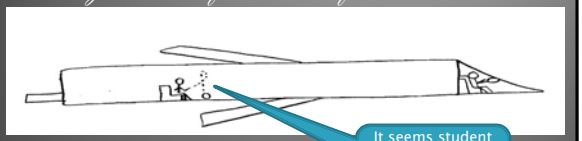
Just upward velocity may be influenced by decreasing gravity

Height decrease gravity → Velocity in freefall

25

Students' reasoning

Ball goes a little forward then falls down



It seems student add the velocities of airplane and ball

Newton first law → Gravity

26

Students' reasoning

- *An object stay at motion unless it acted by an outside force. The ball didn't stop moving until it hit the passenger lap.*

Outside forces has come from the experience of the boundaries blocking things

Forces can act until they become in contact with the object

Newton first law

27

Structure of Written Extended Questions

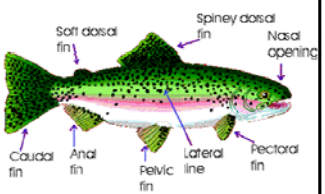
- The question is about a complex system or about a situation or scenario that is rich in detail and can bring Science in to content, the fields of interest can be:
  - *Everyday situations*
  - *Environmental issues*
  - *Science of nature or animals*
  - *Science of medicine*
  - *Science of sports*
  - *Decision making about a real social issue*

28

Example of questions

- How do you think different parts of fish body are similar to airplane design?
  Fins~Wings, Body~Fuselage
- How the fish swimming activity encompasses four forces? Describe how fish use its body to provide thrust?
  Caudal fin and Newton 3rd law

Descriptive to Descriptive



Theoretical to Hypothetical

29

Example of questions cont.

- Describe why swimmer brings his hand out of the water during the return phase of one cycle of the stroke?

Hypothetical concept of swimming → Theoretical Newton 3rd Law

30

Example of questions cont.

- How do you think scale will show a difference weight if the butterfly is sitting on the jar or flapping wings?

Hypothetical concept

Theoretical concept

31

Next Step–Data Collection

- Five universities have been selected for fall
- Certain teaching strategy may skew the performance toward certain type of assessment

32

Thank you

33