Developing High Altitude Balloon Curriculum for Undergraduate Courses

NSF Grant Impact and Example in General Education Chemistry

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Contents of Presentation

- Importance of Curriculum Development
- Curriculum Development for NSF CCLI/TUES Grant
- General Education Chemistry Curriculum Example
  - Taylor University CHE 100 – Chemistry for Living
  - Assessment of Student Learning

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Importance of Curriculum Development

- Survey of 59 faculty at 51 universities training in using Taylor’s HARP (High Altitude Research Platform) system
  - 92% of those responding - “interested” or “very interested” in the development of curriculum using HARP
  - Several faculty interested in developing curriculum for colleagues to use

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Importance of Curriculum Development

HARP Assessment Tool

Learning outcomes increase as number of times implementing in a given course increases

Event Group – Schools that used as an event only

Novice Group – Schools that did 1 launch in the curriculum

Experience Group – Schools that did 2-3 launches in curriculum

Expert Group – Schools did 4 or more launches in curriculum

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Table 1. Significance Levels

Red: $p < .05$

Green : $p < .01$

Blue : $p < .001$

Black: $p > .05$

1: EVENT GROUP	2: NOVICE GROUP	3: EXPERIENCED GROUP	4: EXPERT GROUP
1. Intrinsic Motivation a. Contextualization b. Curiosity c. Challenge d. Control e. Cooperation	**1. Intrinsic Motivation** a. Contextualization b. Curiosity c. Challenge d. Control e. Cooperation	**1. Intrinsic Motivation** a. Contextualization b. Curiosity c. Challenge d. Control e. Cooperation	**1. Intrinsic Motivation** a. Contextualization b. Curiosity c. Challenge d. Control e. Cooperation
2. Valuing Science	**2. Valuing Science**	**2. Valuing Science**	**2. Valuing Science**
3. Application Knowledge a. Apply Problem Solving b. Process of Prototyping c. Process of Evaluation d. Documentation and Reports	**3. Application Knowledge** a. Apply Problem Solving (decrease) b. Process of Prototyping c. Process of Evaluation d. Documen tation and Reports	**3. Application Knowledge** a. Apply Problem Solving b. Process of Prototyping c. Process of Evaluation d. Documentation and Reports	**3. Application Knowledge** a. Apply Problem Solving b. Process of Prototyping c. Process of Evaluation d. Documentation and Reports
4. Metacognitive Processes a. Metacognitive Planning b. Metacognitive Assessing c. Metacognitive Monitoring	**4. Metacognitive Processes** a. Metacognitive Planning b. Metacognitive Assessing c. Metacognitive Monitoring	**4. Metacognitive Processes** a. Metacognitive Planning b. Metacognitive Assessing c. Metacognitive Monitoring	**4. Metacognitive Processes** a. Metacognitive Planning b. Metacognitive Assessing c. Metacognitive Monitoring
5. Cognitive Skills	**5. Cognitive Skills**	**5. Cognitive Skills**	**5. Cognitive Skills**
6. Content Knowledge a. Primary Technical Knowledge b. Learning Cycle Knowledge c. Operations Knowledge	**6. Content Knowledge** a. Primary Technical Knowledge b. Learning Cycle Knowledge c. Operations Knowledge	**6. Content Knowledge** a. Primary Technical Knowledge b. Learning Cycle Knowledge c. Operations Knowledge	**6. Content Knowledge** a. Primary Technical Knowledge b. Learning Cycle Knowledge c. Operations Knowledge

HARP Assessment Tool

Pre and Post Test (Self Evaluation)

- Developed by Prof. Steve Snyder, Professor of Psychology & students at Taylor University with Science faculty
- Learning areas assessed:
  - Intrinsic Motivation
    - Contextualization
    - Curiosity
    - Challenge
    - Control
    - Cooperation
  - Valuing Science
  - Application Knowledge
    - Problem solving
    - Prototyping
    - Evaluation
    - Documentation
  - Metacognitive Processes
    - Planning
    - Assessing
    - Monitoring
  - Cognitive Skills
  - Content Knowledge

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HARP Assessment Tool

Pre and Post Test (Self Evaluation)

- Excellent Reliability
  - Pre-test Cronbach's Alpha = 0.976
  - Pos-ttest Cronbach's Alpha = 0.965
- Excellent Validity
  - Developed by experts in educational assessment and science education
  - Consistent increase from pre- to post-test
  - Consistently higher score for those with more science education
- 15 Universities in 29 Courses assessed
- Reports summarizing results with recommendations by Dr. Snyder & students
  - Improve courses
  - Obtain grant funding

Bethany Smith and Rachel Tomasik (Taylor Students) available during the conference for consultation

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NSF CCLI/TUES Grant

- Awarded to Taylor University (2010-2013)
- Several Curricula to be Developed
  - Funds for stipends and supplies
  - Open to faculty from all higher education institutions
- Curricula should:
  - Be used by many universities across the U.S. and/or
  - Be used in multiple courses (modules that teach specific content)

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NSF CCLI/TUES Grant

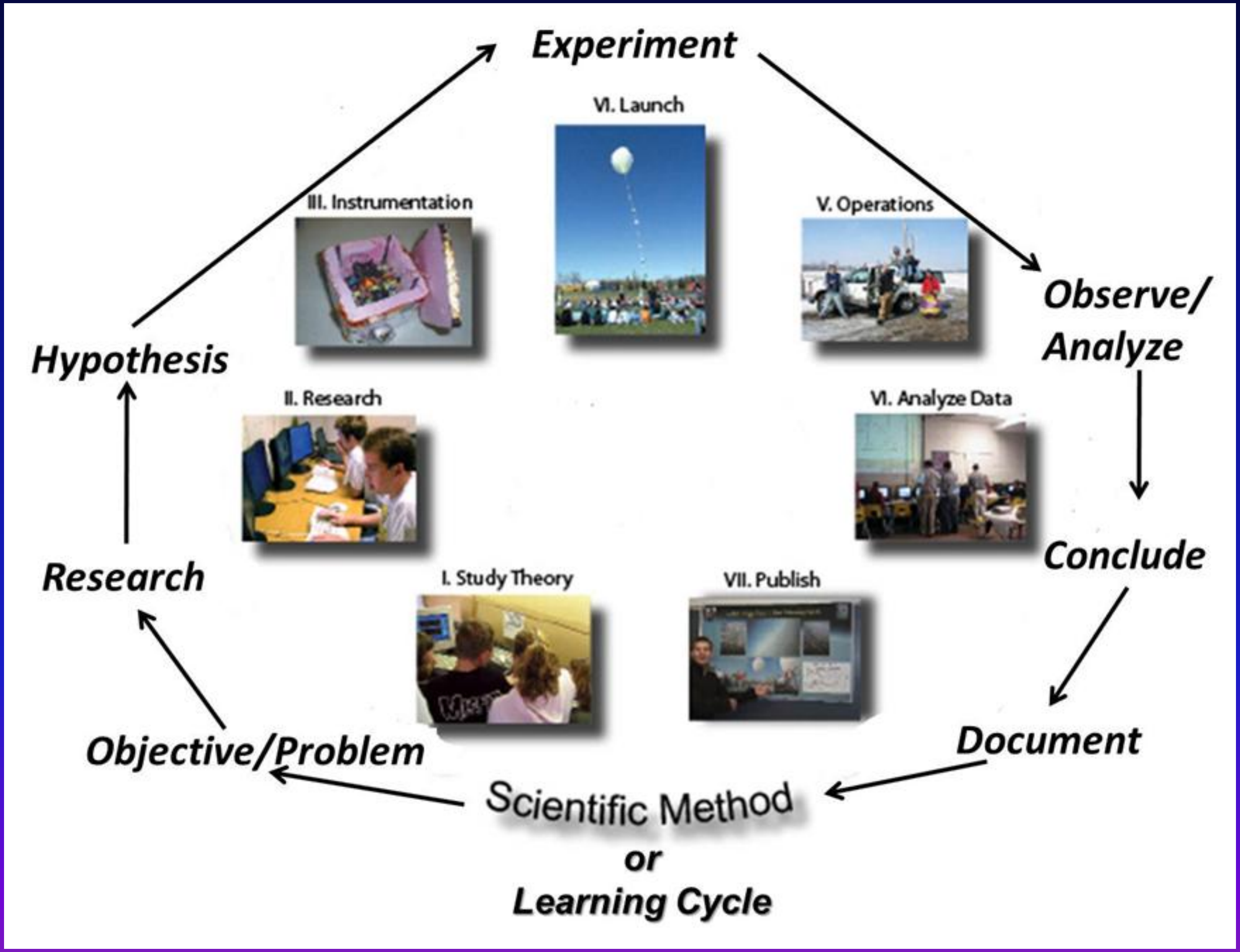
Requirements for Developing Curriculum

- Clear and specific learning objectives
- Detailed information on experiments including specific procedures, list and description of equipment, etc.
- Detailed description of data analysis procedures
- Detailed description of what students need to have mastered before performing the HARP experiment
- Assessment of achievement of learning objectives after testing curriculum in a classroom.

General Education Chemistry Example

- Taylor University CHE 100 – Chemistry for Living
- Learning Objectives
  - Scientific Method – hands on, real world experience
    - Challenges, disappointment, excitement, achievement
  - Critical Thinking Skills
    - Prediction
    - Problem Solving
    - Analysis
    - Hypothesis Testing (Scientific Method)
  - Metacognitive Processes
    - Planning
    - Monitoring
    - Assessing
  - Application of Chemistry Topic taught in Class

Scientific Method



Overview of Curriculum

- Students given topic related to course (Greenhouse gases, UV, Freezing Point Depression, Solar Cells)
- Students responsible for
  - Selecting objective/problem
  - Literature research on topic
  - Coming up with Hypothesis
  - Developing experiment to test Hypothesis using HARP
  - Performing experiment through HARP launch
  - Analyzing data
  - Obtaining Conclusion wrt Hypothesis
  - Documenting Scientific Method Process
- Students work in groups of 4-5
- 6 week period
  - Three Labs (2 hours each)
  - Launch between Labs 1 & 2
- Presentation or Poster and final report required

Overview of Curriculum

- Students need to know:
  - Changes in variables during ascent/descent of balloon
  - Content from course on topics assigned
- Sensors available with real time data streaming to earth
  - Altitude
  - Temperature
  - Pressure
  - Humidity
  - Visible Light
  - UV
  - IR
  - Radiation (Geiger Counter)
  - Acceleration (Accelerometer)
  - Video cameras (not streamed)

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Overview of Curriculum

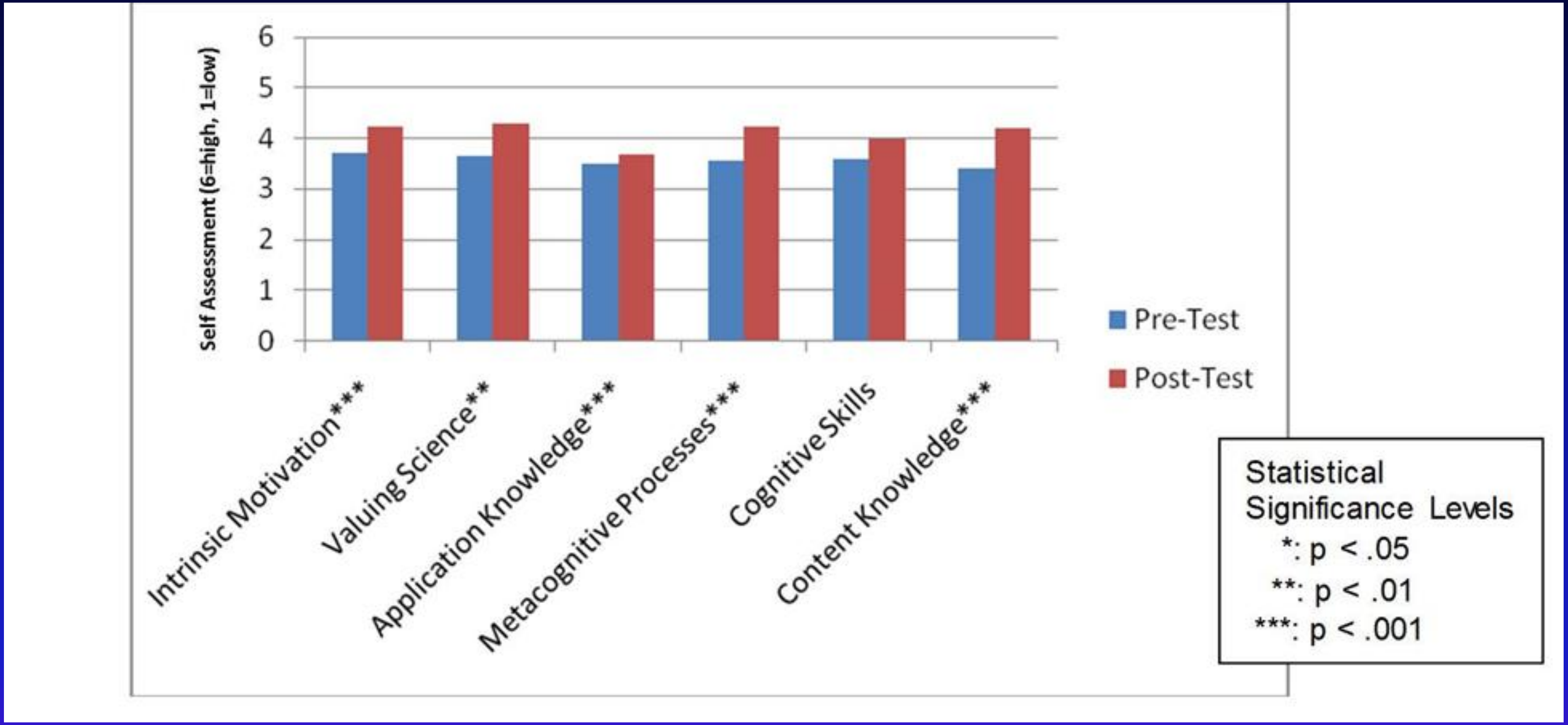
- Critical Thinking
  - Prediction
    - Formulation of hypothesis
    - Experiment Development
      - Evaluation of effectiveness of experiment
      - Improvement of experiment
  - Problem Solving
    - Brainstorm potential flaws and/or problems with experiment
    - Determine and implement solutions to problems
  - Analysis
    - Thorough and detailed analysis of data
    - Looking at data many times

Overview of Curriculum

- Metacognitive Processes
  - Planning
    - Formulation of hypothesis
    - Development of experiment
  - Monitoring
    - Performing experiment optimally
    - Preventing major problems/failures
  - Assessment
    - How well did we do in meeting objective?
    - How can process and experiment be improved?

Assessment Results

Results after 4th implementation of HARP into course



<u>**Practical Significance**</u>

Intrinsic Motivation (cta^2 = 0.28)

Application Knowledge (cta^2 = 0.46)

Metacognitive Processes (cta^2 = 0.35)

Content Knowledge (cta^2 = 0.35)

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Assessment Results

Variable
1. Intrinsic Motivation
a. Contextualization
b. Curiosity
c. Challenge
d. Control
e. Cooperation
2. Valuing Science
3. Application Knowledge
a. Apply Problem Solving
b. Process of Evaluation
c. Documentation and Reports
4. Metacognitive Processes
a. Metacognitive Planning
b. Metacognitive Assessing
c. Metacognitive Monitoring
5. Cognitive Skills
6. Content Knowledge
a.a. Primary Technical Knowledge
b. Scientific Method Knowledge

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Take Aways

- ***Curriculum development is critical*** for the success of high altitude ballooning as a tool to significantly impact STEM learning
- ***Faculty can develop curricula*** through Taylor University's NSF CCLI/TUES Grant
- ***HARP Assessment Tool is reliable, valid and proven*** to quantitatively assess student learning, improve curricula, and obtain grant funding

  See Bethany Smith or Rachel Tomasik
- ***Taylor's Gen Ed Chemistry has shown success*** in obtaining practically significant increases in learning outcomes