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Design and Assessment of Deep and Active Learning in Science, Technology, Engineering, and Mathematics (STEM) Education

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Design and Assessment of Deep and Active Learning in Science, Technology, Engineering, and Mathematics (STEM) Education

Presentation at HKAECT 2017
June 15, 2017
Hong Kong
Introduction of Presenters

- Dr. Liz Johnson, James Madison University
- Dr. Juhong Christie Liu, James Madison University
- Dr. Jin Mao, Wilkes University
- Professor Shelley Jaye, Northern Virginia Community College
- Dr. Ritu Kansal, Northern Virginia Community College

Collaborative Research:
Open Access Blended Learning Modules for Teaching Laboratory Methods: Developing Scientific Skills for Undergraduates
Overview and Scholarly Significance

STEM in the U.S. context

The need for design and assessment strategies that can
- help create deep and active learning, creativity, critical thinking, learner autonomy and metacognition, and the ability to learn in this fast-changing society;
- enable students to master the knowledge foundation of scientific concepts but also learn the ways of thinking as scientists design.

Open Educational Resources (OER) and STEM education
“In the deep [learning] approach, the intention to extract meaning produces active learning processes that involve relating ideas and looking for patterns and principles on the one hand, and using evidence and examining the logic of the argument on the other. The approach also involves monitoring the development of one’s own understanding”

(Entwistle, 2000, p. 3)
Taxonomy of Significant Learning

- **Learning How to Learn**
  - Becoming a better student
  - Inquiring about a subject
  - Self-directing learners

- **Foundational Knowledge**
  - Understanding and remembering:
    - Information
    - Ideas

- **Application**
  - Skills
  - Thinking:
    - Critical, creative, & practical thinking
    - Managing projects

- **Human Dimension**
  - Learning about:
    - Oneself
    - Others

- **Integration**
  - Connecting:
    - Ideas
    - People
    - Realms of life

Fink. 2013
Concrete Experience

Reflective Observation

Perceiving

Processing

Applications

Perceiving

Abstract Conceptualization

Kolb, D. A. (2000)
ID Strategies for Student-Centered Learning

» Flipped Classroom/Flipped Learning
» Problem-based Learning / Project-based Learning
» Process-Oriented Guided Inquiry Learning (POGIL)
» Team-based Learning
» PLTL
Process-Oriented Guided Inquiry Learning

- Selected ID Strategy for NSF Project
POGIL Activity Design

1. Define Learning Objectives
2. Identify Equipment & Facility
3. Develop Models/Scenarios
4. Create Key Questions (CTQs)
5. Develop Self-Assessment
6. Develop Application Cases
“Thin sections are used for mineral identification, petrographic analysis to classify rocks, and textural analysis to describe how a rock is formed.” Now that you and your peer classmates were requested by a local mineral society to analyze a piece of chlorite schist.
Design - Content Presentation

https://youtu.be/Lm47uPCtYbs
What are the core stages of preparing a thin section?

A power-driven, diamond impregnated lapping wheel is used for

- Cutting the original specimen
- Mounting the chip
- Cleaning the section with abrasive powder **
- Sliding labels

Self-Assessment:
Interactive Video: [https://www.playposit.com/play/589222](https://www.playposit.com/play/589222)
A hotspot sample: [https://h5p.org/node/70886](https://h5p.org/node/70886)
A self quiz sample: [https://h5p.org/node/70882](https://h5p.org/node/70882)
<table>
<thead>
<tr>
<th>Procedure</th>
<th>Description</th>
<th>Redesign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Label the activity</td>
<td></td>
</tr>
<tr>
<td>Why</td>
<td>Explain the reasons for learning</td>
<td></td>
</tr>
<tr>
<td><strong>Learning Objectives</strong></td>
<td><strong>List what is to be learned</strong></td>
<td></td>
</tr>
<tr>
<td>Success Criteria</td>
<td>Determine the desired outcomes and abilities that will be used to measure performance and achievement</td>
<td></td>
</tr>
<tr>
<td>Prerequisite</td>
<td>Identify the prior skills and knowledge that are needed</td>
<td></td>
</tr>
<tr>
<td>Resources and Information</td>
<td>Provide information needed for the activity. Additional information can be provided to help students consolidate their learning after they have completed the “key questions.” List essential references related to the activity</td>
<td></td>
</tr>
<tr>
<td>Glossary</td>
<td>Provide key terminology</td>
<td></td>
</tr>
<tr>
<td>Plan and/or Tasks</td>
<td>List the plan and/or tasks for meeting the learning objectives</td>
<td></td>
</tr>
<tr>
<td>Key Questions</td>
<td>Pose questions that guide the execution of the plan and/or tasks, the exploration of the model, and processing of the information and resources in order to stimulate thought, introduce or form concepts, and construct understanding</td>
<td></td>
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<tr>
<td>Skill Exercises</td>
<td>Apply the new knowledge in simple situations and familiar contexts</td>
<td></td>
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<tr>
<td>Problems</td>
<td>Use the knowledge in new or real-world contexts requiring transference, synthesis, and integration of concepts</td>
<td></td>
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<tr>
<td>Self Assessment</td>
<td>Have students identify what has been done well and develop strategies for improvement</td>
<td></td>
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</tbody>
</table>

Assessment Design for STEM Learning

- Instruments - MLLI & Science Competency
- Observation
- Student Research Papers
- Rubric
Assessment of STEM Learning - Observation
Please indicate your agreement with each of the following statement by selecting ONE option.

When performing experiments in my geoscience laboratory course this semester, I expect...

<table>
<thead>
<tr>
<th>Strongly Disagree (0%)</th>
<th>Disagree (25%)</th>
<th>Neutral (50%)</th>
<th>Agree (75%)</th>
<th>Strongly Agree (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>to learn laboratory skills that will be useful in my life.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>to worry about finishing on time.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>to make decisions about what data to collect.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>to feel unsure about the purpose of the procedures.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>to experience moments of insight.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
COLLABORATIVE RESEARCH:
Open Access Blended Learning Models for Teaching Laboratory Methods: Developing Scientific Skills for Undergraduates

This material is based upon work supported by the National Science Foundation award 1611798 to James Madison University and Wilkes University, and award 1611917 to Northern Virginia Community College. The course modules will be immediately and continuously accessible by instructors and students from JMU, NOVA, and any other college or university through the Lumen Learning Open Courseware website.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.


