Student Engagement in Authentic Research Design

Laboratory curriculum based on features of authentic learning:\n
- Real-World Relevance
- Ill-Defined Problem ✓
- Sustained Investigation
- Multiple Sources and Perspectives
- Collaboration
- Reflection
- Polished Procedure
- Multiple Interpretations and Outcomes

Misconceptions about authentic learning:\n
1. Any learning context that is not completely authentic is fraudulent
2. Authentic Tasks must be elaborate and complex

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Authentic Research Problems

Traditional experiments were refocused around a set of problems that are routinely encountered by practicing synthetic chemists.

Problem Features:
- ill-defined
- Real-world context
- Balanced difficulty/accessibility
- Sustainable:
  1. Open (many possible solutions)
  2. Cycled in/out
Traditional Experiment Refocused Around an Authentic Problem (Chemistry 216)

**TRADITIONAL Lab Experiment**

**Objective:** Perform the Wittig reaction according to the procedure provided and use standard methods to characterize your product.

**PROBLEM-BASED Lab Experiment**

**Objective:** The Wittig reaction that typically uses dichloromethane as a solvent, which is bad for the environment. Working with a group of students:

1) Propose an alternative method(s) for performing the reaction that is more environmentally friendly
2) Form a hypothesis about your alternative and design an experiment to test it
3) Do your experiment
4) Evaluate whether your method worked as well as or better than the standard procedure.
Traditional Experiment Refocused Around an Authentic Problem (Chemistry 216)

TRADITIONAL Lab Experiment
Objective: Perform this Wittig reaction according to the procedure provided and use standard methods to characterize your product.

PROBLEM-BASED Lab Experiment
Objective: The Wittig reaction typically uses dichloromethane as a solvent, which is bad for the environment.

Working with a group of students:

1) Propose an alternative method(s) for performing the reaction that is more environmentally friendly
2) Form a hypothesis about your alternative and design an experiment to test it
3) Implement your experiment
4) Evaluate whether your method worked as well as or better than the standard procedure
Traditional Experiment Refocused Around an Authentic Problem (Chemistry 482)

**PROBLEM-BASED Lab Experiment**

**Objective:** Metal-Organic Frameworks (MOFs) are used to capture and selectively separate certain molecules. What features govern selectivity?

Working with a group of students:

1) Develop a hypothesis about size/shape/electronic constraints for uptake within the MOF pore
2) Develop/modify an experiment to test hypothesis, given a library of molecules
3) Perform experiment and compile group data on a Google Spreadsheet
4) Use group data and entire class data to refute/confirm hypothesis
Student-centered Research Design

**Process:**

1. Students complete short online pre-labs and quizzes

2. Instructor models experimental design process and facilitates group discussion

3. Students work in small groups to brainstorm solutions and design experiment

4. GSI evaluates proposed experiment and provides timely feedback

5. Students implement experiment in lab, GSI helps students troubleshoot ‘micro-problems’

6. Students reflect on experimental results in individual writing assignments
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**GSI assumes a stronger advisory role**
Student-directed Engagement with Chemistry Content

Audio Recordings collected during student planning sessions revealed that students spend around 30% of their time defining the problem through student-directed discussion of content.

![Pie chart showing time spent on different tasks: defining problem (30%), analyzing (14%), planning (13%), brainstorming (4%), other (39%).]
Questions or interested in adapting the ARD model in a lab class that you teach?

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