Writing Inquiry-Based Activities for Your Classroom

October 5, 2012
Laura Frost, Ph.D.
lfrost@gcu.edu
X-1434

Director, Whitaker Center for STEM Education
Professor of Chemistry

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time Allotted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry and Guided Inquiry</td>
<td>15 min.</td>
</tr>
<tr>
<td>(What does it look like? How does it work?)</td>
<td></td>
</tr>
<tr>
<td><em>Process Oriented</em> Guided Inquiry Learning (POGIL)</td>
<td>25 min.</td>
</tr>
<tr>
<td>(Why include the “process” component?)</td>
<td></td>
</tr>
<tr>
<td>Student Success with Guided Inquiry</td>
<td>5 min.</td>
</tr>
<tr>
<td>Q &amp; A</td>
<td>10 min.</td>
</tr>
<tr>
<td>Break</td>
<td>5-10 min.</td>
</tr>
<tr>
<td>Implementation</td>
<td></td>
</tr>
<tr>
<td>Lower Level vs. Upper Level Courses</td>
<td>5 min.</td>
</tr>
<tr>
<td>Components of an Activity</td>
<td>5 min.</td>
</tr>
<tr>
<td>Developing Your Activity</td>
<td>30-40 min.</td>
</tr>
<tr>
<td>Final Q &amp; A, wrap-up, return surveys</td>
<td>5-10 min.</td>
</tr>
</tbody>
</table>
What is Inquiry Based Instruction?

“The creation of a classroom where students are engaged in essentially open-ended, student-centered, hands-on activities.” Colburn 2000.

Watch it in Action!

An Inquiry-Based Approach
Level of inquiry defined by the amount of information given to the student

In the lab, Bell, Smentana and Binns define these levels as:

<table>
<thead>
<tr>
<th>Level</th>
<th>Question</th>
<th>Method</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirmation</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Structured</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guided</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Translated to a classroom,

<table>
<thead>
<tr>
<th>Level</th>
<th>Topic</th>
<th>Data</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirmation</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lecture</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Structured</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lect.-Interact.</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Guided</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discovery</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Students working in groups

• Learn more
• Understand more
• Feel better about themselves
• Feel better about the class
• Have a more positive attitude regarding the subject area, course, and instructor


Slavin, R.E. “Research for the Future: Research on Cooperative Learning and Achievement: What we know, what we need to know”, Contemporary Educational Psychology, 21, 1996.

What do we know about teaching and learning?

› Teaching by telling does not work
› Students learn more when they construct their own understanding
› Discussion with peers is crucial
› Reflection is a key part of learning


Goals of a Guided Inquiry Approach

- Students are actively engaged and thinking in class
- Students discover concepts (rather than memorize facts)
- Students learn course content & key process skills

Information Processing Model

- Events
- Observations
- Instructions
- Perceptions
- Working Memory
- Storing
- Retrieving
- Long Term Memory
- Students

previous knowledge
preferences
misconceptions
biases
likes
dislikes

Constructivist Model of Learning

“Learning is not the transfer of material from the head of the teacher to the head of the learner intact, (but) the reconstruction of material in the mind of the learner.”

“It is an idiosyncratic reconstruction of what the learner…thinks she understands, tempered by existing knowledge, beliefs, biases, and misunderstandings.”

Learning Cycle

- Parallels the “scientific method”
- Provides context for introduction of new terms
- Explicitly provides opportunities for critical thinking
A Learning Cycle Activity

- Ideas do not appear in the brain fully formed
- Being wrong is a stage on the way to being more right
- Learning is a process wrought with effort, frustration, and error.

The POGIL approach – ONE guided inquiry approach that works

Process Oriented Guided Inquiry Learning
www.pogil.org
Key Process Skills in Learning

- Cognitive
  - Information processing
  - Critical thinking
  - Problem solving
  - Research
- Social
  - Communication
  - Teamwork
  - Management
- Affective
  - Value development
  - Personal development
  - Esthetic development

Research on Learning

<table>
<thead>
<tr>
<th></th>
<th>Traditional Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof’s Job</td>
<td>Lecture</td>
</tr>
<tr>
<td>Source of Material</td>
<td>Professor</td>
</tr>
<tr>
<td>Student role</td>
<td>Passive listener</td>
</tr>
<tr>
<td>Learning</td>
<td>Memorize notes after class</td>
</tr>
<tr>
<td>Emphasis</td>
<td>Competition</td>
</tr>
</tbody>
</table>
Research on Learning

<table>
<thead>
<tr>
<th></th>
<th>Traditional Classroom</th>
<th>Inquiry Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof’s Job</td>
<td>Lecture</td>
<td>Help students learn</td>
</tr>
<tr>
<td>Source of Information</td>
<td>Professor</td>
<td>Specially designed “Learning Cycle” Activities</td>
</tr>
<tr>
<td>Student role</td>
<td>Passive listener</td>
<td>Active group discussion</td>
</tr>
<tr>
<td>Learning</td>
<td>Memorize notes after class</td>
<td>Discover concepts during class, reinforce after class</td>
</tr>
<tr>
<td>Emphasis</td>
<td>Competition</td>
<td>Community, Co-operation</td>
</tr>
</tbody>
</table>

Implementation Tools

- Learning teams
- Guided-inquiry activities to develop understanding
- Questions to promote critical thinking
- Problem solving
- Reporting
- Metacognition
- Individual accountability
Group Activity

- Time for you to get involved!

Is it Working?
What is “Success”? 

- We define “success” as the achievement of a grade of C- or higher (ABC)
- “Lack of success” includes grades in the D range, F range, and withdrawals (DFW)
- More detailed grade distributions will be shown, but analysis will be based on this definition of “success”

POGIL - Organic I at a Large Public University

Withdrawals and Common Final Exam Scores - Fall 2000

LECTURE n = 109

- A 12%
- B 19%
- C 16%
- D 5%
- F 1%
- Withdraw 47%

POGIL n = 75

- A 9%
- B 32%
- C 31%
- D 15%
- F 1%
- Withdraw 12%

Chi squared = 19.1 Alpha <0.005
POGIL – Chemistry for Health Professions at Regional Comprehensive University

- Sections of about 48 students
- POGIL F2006 – S2012: n = 456
- No pre-req for course
- Same instructor “before” and “after”


Final Grade Distribution
Health Professions Chemistry

Final Grade Distribution

Lecture-Interactive (N=285 students)

- A 20%
- B 40%
- C 25%
- D 7%
- F 8%

Guided-Inquiry (N=456 students)

- A 30%
- B 36%
- C 24%
- D 7%
- F 3%

Assessment Pre-Quiz for Organic 2

- Large public university
- Classes of about 250
- Unannounced quiz given on first day of Organic 2
- Some students took Organic 1 with lecture; two different instructors
- Some students were in a POGIL section of Organic 1

---

Retention of Learning

- Organic 2 Pre-quiz Results
  (Lecture vs. POGIL Organic 1)

POGIL—Organic 2 at a Tier 1 Midwest Liberal Arts College

- Comparison of grades in a single section of Organic 2
  - Some students took Organic 1 with Guided Inquiry
  - Some students took Organic 1 with lecture
  - Not all students from Organic 1 enrolled in this section of Organic 2

Is Guided Inquiry Organic 1 Preparation for Organic 2 Lecture?

- Grade in Organic 2, Winter Quarter

<table>
<thead>
<tr>
<th>Grade</th>
<th>% of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/A-</td>
<td>10</td>
</tr>
<tr>
<td>B+/B</td>
<td>20</td>
</tr>
<tr>
<td>B-/C+</td>
<td>15</td>
</tr>
<tr>
<td>C/C-</td>
<td>30</td>
</tr>
<tr>
<td>D/F/ Drop/Late</td>
<td>10</td>
</tr>
<tr>
<td>Did not go on to Organic 2</td>
<td>15</td>
</tr>
</tbody>
</table>

- Students from section GI, Fall quarter
- Students from section L, Fall quarter
Questions?

• Take one minute to write down any questions that you have, then think about which question is most important to you.

• As a group, take three minutes to discuss your questions and come up with a list of up to three questions you would like to ask, in rank order of importance.

BREAK
The level of learning you reach in class necessarily differs.

- **Exploration (E)**: Prof's job is to facilitate learning.
- **Invention (I)**: Source of information is activities.
- **Application (A)**: Activity content is to invent or form concepts.

---

**Implementation Differs With Course Level**

<table>
<thead>
<tr>
<th></th>
<th>Introductory Course</th>
<th>Upper Level Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof's Job</td>
<td>Facilitate learning</td>
<td>Clarify assignment and facilitate learning</td>
</tr>
<tr>
<td>Source of Information</td>
<td>Activities</td>
<td>Textbook, assignments, professor (some)</td>
</tr>
<tr>
<td>Activity Content</td>
<td>Invent concepts OR Form concepts</td>
<td>Form Concepts OR Apply Concepts</td>
</tr>
<tr>
<td>Learning</td>
<td>Concept development during class; reinforce after class through skill exercises</td>
<td>Concept development may be prior to class; concept application during class; further problem solving after class</td>
</tr>
<tr>
<td>Accountability</td>
<td>Daily quizzes</td>
<td>Assignments due prior to class</td>
</tr>
</tbody>
</table>
Creating a Guided-Inquiry Activity

- Model
- One to three concepts to be developed
- Key Questions that guide to desired concepts
- Application can be either within the key questions or exercises, or both.
- Process skill development takes place in the context of the activity.

Note: This is a general template. There is no single correct way to write an activity. The subject matter often dictates how the activity is written.

Types of Activities

- Learning Cycle Activities
- Application Activities

Which you choose depends on the topic
- Could be a combination of both
Key Questions

Learning Cycle Phase

- Exploration (E)
  - Examining the model, collecting information

- Concept Invention (I)
  - Finding patterns in data, converging on a concept, questions analyze, compare, contrast.

- Application (A)
  - Applying the newly developed concept to a new context.

Go back to the activity and identify questions 1-5 as either E, I, or A.

Key Questions

- Directed
  - What are the three different units of length used in the Model?
  - What type of bacteria is found on this plate?
  - What is the charge on a sulfate anion?
  - What is the area of a circle with a radius of 3.5 cm?

- Convergent
  - Which molecule in the list would you predict to have the highest boiling point?
  - Based on the examples given, propose a definition for the term “sunk costs.”
  - What is the mathematical relationship represented by the data points on the graph?
  - What evidence do you have to support your conclusion?

- Divergent
  - Where would be the optimal location for a new water treatment plant?
  - How might scientists experimentally determine the mass of a proton?
  - Why are the questions in this activity ordered in the way they are?
  - What is the most efficient way to dissolve 10 grams of salt in a sample of water?

Based on the examples given here, develop a group consensus on definitions for each type of question. Each definition should be at most two sentences.
Writing Your Activity

- Handout

TITLE

- What do you want your students to know?
- One to Three concepts, could be separated into parts.
**Model**

- Several small models is better than one big one. Chunkify.
- One main point per model.
- Contains information that you want students to pull out in questions.

**Questions**

- Follow the Learning Cycle.
- First questions should be directed, then convergent, leading to a concept.
- Guide students to the concept.