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Guided Inquiry in an Upper Level Vs. Lower Level Undergraduate Course

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Guided Inquiry in an Upper Level vs. Lower Level Undergraduate Course

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Background

Conventional
• Teaching is telling
• Knowledge is facts
• Learning is recall

New Paradigm
• Teaching is enabling
• Knowledge is understanding
• Learning is an active reconstruction of subject matter

Outline

• Guided Inquiry Defined
• Learning through Constructivism
  – (how high is the level of learning?)
• Inquiry Instruction
  – Varieties: POGIL vs. Team-Based Learning
• Assessing Student Learning
  – Is it Working?

Definitions: 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.

Levels of inquiry can be distinguished 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>x</td>
<td></td>
</tr>
<tr>
<td>Guided</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Translated to the 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></td>
</tr>
<tr>
<td>Lect.-Interact.</td>
<td>x</td>
<td>x</td>
<td></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>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Guided Inquiry is based on the Constructivist Model of Information Processing

Events Observations Instructions
\[\text{Percipitation} \rightarrow \text{Working Memory} \rightarrow \text{Storing} \rightarrow \text{Retrieving} \rightarrow \text{Long Term Memory}\]

previous knowledge preferences misconceptions biases likes dislikes


A typical implementation involves the Learning Cycle
(Karplus, Piaget)

E → I → A

Exploration Concept Invention Application


Five Key Ideas about Learning
(Bransford, et. al.)

People learn by:
• Constructing their own understanding based on their prior knowledge, experiences, skills, attitudes, and beliefs.
• Following a learning cycle of exploration, concept formation, and application.
• Connecting and visualizing concepts and multiple representations.
• Discussing and interacting with others.
• Reflecting on progress and assessing performance.

Implementation Tools for Inquiry

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

Learning Levels: Gagné and Briggs
(1974)

Lowest to Highest

- Information
  • Recall
- Concepts
  • Classifies
- Rules (simple)
  • Demonstrates
- Higher Rules (complex)
  • Generate

What level of learning is expected?

• Introductory Course
  – Does not assume prior knowledge of concepts from which to build

• Upper Level Course
  – Assumes prior knowledge in the discipline on which to build.
The level you reach in class differs

<table>
<thead>
<tr>
<th>Exploration</th>
<th>Concept Invention</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>Highest</td>
<td></td>
</tr>
</tbody>
</table>

**Implementation Similarities**

<table>
<thead>
<tr>
<th></th>
<th>4-5 students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td></td>
</tr>
<tr>
<td>Roles</td>
<td>Manager, Recorder, Presenter, Spy/Technician</td>
</tr>
<tr>
<td>Metacognition</td>
<td>Feedback sheet</td>
</tr>
<tr>
<td>Attitude</td>
<td>Initial discomfort</td>
</tr>
</tbody>
</table>

**Implementation Differences**

<table>
<thead>
<tr>
<th></th>
<th>Introductory Course</th>
<th>Upper Level Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>Discover concepts during class, reinforce after class</td>
<td>Discover concepts prior to class, apply concepts during class</td>
</tr>
<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>Accountability</td>
<td>Daily quizzes</td>
<td>Assignments due prior to class</td>
</tr>
</tbody>
</table>

**Guided Inquiry Methods Necessarily Vary with Level of Course**

- Cooperative vs. Team-based
  - Process Oriented Guided Inquiry Learning (POGIL) [www.pogil.org](http://www.pogil.org)
  - Team-based Learning (TBL) [teambasedlearning.apsc.ubc.ca](http://teambasedlearning.apsc.ubc.ca)

**Is It Working?**

Courses: CHEM 1140/5541

Student Learning

<table>
<thead>
<tr>
<th>Course Grades</th>
<th>Final Exam Grades</th>
<th>Common Final Exam Questions</th>
<th>Cognitive Analysis</th>
<th>Topic Analysis</th>
</tr>
</thead>
</table>

Student Perceptions

- Formative Evaluations
- SALG survey

Michaelsen et al., Team-Based Learning, 2002
Final Grade Distribution
CHEM 1140
Lecture-Interactive (N=285 students)
Inquiry (N=271 students)

DFW Rates – CHEM 1140
Lecture-Interactive (5 sem, N=304)
DFWs: 20%, 8% were W

Inquiry 1st time (POGIL)
DFWs: 24%, 9% were W

Inquiry 2nd-6th time combined
DFWs: 14%, 8% were W

DFW Rates – CHEM 5541
Lecture-Interactive (2 sem, N=45)
DFWs: 31%, 13% were W

Inquiry 1st time (1 sem, N=34)
DFWs: 18%, 6% were W

Summary Final Grades
At both levels
• More students passing the class
• DFW rates overall lowered

Final Exam Score – CHEM 1140
(6 semesters of inquiry data, all questions)
Lecture-Interactive Average (N=274)
\[60\% \pm 16\]

POGIL Average (N=266)
\[65\% \pm 13\]

Significant 99% confidence level
Final Exam Score – CHEM 5541
(One semester of inquiry data, common questions)
Lecture-Interactive Average (N=43)  
66.7% ± 2.4
POGIL Average (N=34)  
70.5% ± 2.7
Looks higher, but not statistically different

Summary Final Exam Scores
• Introductory course final exam score higher
• Upper level course, higher trend.

Common Final Exam Questions
Learning Level

Intro. Course: Common Final Exam Questions Grouped by Learning Level

The Later Final Exams Were More Difficult

The Later Final Exams Were More Difficult
Upper Level: Common Final Exam Questions Grouped by Learning Level

Inquiry vs. L-I by Learning Levels

Common Final Exam Questions

Topic

Measured as % of students getting complete correct answer

Change = average of all Inquiry sections (6 semesters) vs. Lecture Interactive (F '05)

Introductory Course: Average Difference in Correct Responses

Upper Level Course: Average Difference in Correct Responses

* All semesters contained this topic

Conclusion 1 – Final Exam Analysis

• LEARNING LEVEL
  Inquiry did as well often better than L-I
  In the Intro course demonstrate problem solving.

• TOPIC
  Inquiry overall learned more at both levels

Assessing Student Perceptions

Formative

Can we correct students’ difficulties with guided inquiry learning?
Formative Evaluation Parameters

<table>
<thead>
<tr>
<th></th>
<th>F06</th>
<th>Sp07</th>
<th>Su07</th>
<th>F07</th>
<th>Sp08</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>67</td>
<td>31</td>
<td>30</td>
<td>30</td>
<td>32</td>
</tr>
</tbody>
</table>

**Q1:** What has been the most positive part of your group work experience in this class?

**Q2:** What has been the most negative part of your group work experience in this class?

**Q3:** If you could change anything about the way this course is designed, what would you change?

### Positive

<table>
<thead>
<tr>
<th></th>
<th>F06</th>
<th>Sp07</th>
<th>Su07</th>
<th>F07</th>
<th>Sp08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socialization¹</td>
<td>26%</td>
<td>16%</td>
<td>13%</td>
<td>27%</td>
<td>22%</td>
</tr>
<tr>
<td>Learning Process²</td>
<td>21%</td>
<td>32%</td>
<td>23%</td>
<td>27%</td>
<td>9%</td>
</tr>
<tr>
<td>Problem Solving³</td>
<td>53%</td>
<td>52%</td>
<td>53%</td>
<td>47%</td>
<td>50%</td>
</tr>
</tbody>
</table>

¹ Making friends, meeting nice/new people
² Staying focused/alert, learning to work w/group, team skills
³ Help in interpreting and figuring out problems in groups

### Negative

<table>
<thead>
<tr>
<th></th>
<th>F06</th>
<th>Sp07</th>
<th>Su07</th>
<th>F07</th>
<th>Sp08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Process¹</td>
<td>12%</td>
<td>32%</td>
<td>23%</td>
<td>17%</td>
<td>31%</td>
</tr>
<tr>
<td>Learning Process²</td>
<td>22%</td>
<td>26%</td>
<td>37%</td>
<td>33%</td>
<td>37%</td>
</tr>
<tr>
<td>Worksheets³</td>
<td>23%</td>
<td>29%</td>
<td>7%</td>
<td>17%</td>
<td>16%</td>
</tr>
<tr>
<td>Explanations⁴</td>
<td>26%</td>
<td>---</td>
<td>7%</td>
<td>30%</td>
<td>---</td>
</tr>
</tbody>
</table>

1Rudeness, feeling inadequate
2Group lack of knowledge, socialization instead of on-task, loss of learning and lack of feedback
3Lost in worksheets, hard, no confirmation of answers, hard to get used to these
4Not enough explanation, guidance, clarity on if we are doing it right

### Change

<table>
<thead>
<tr>
<th></th>
<th>F06</th>
<th>Sp07</th>
<th>Su07</th>
<th>F07</th>
<th>Sp08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanations¹</td>
<td>55%</td>
<td>46%</td>
<td>27%</td>
<td>60%</td>
<td>47%</td>
</tr>
<tr>
<td>Groups²</td>
<td>22%</td>
<td>23%</td>
<td>10%</td>
<td>20%</td>
<td>41%</td>
</tr>
</tbody>
</table>

¹ Add more instructor explanations, more teacher/student interaction
² No more groups, lecture and then group work

### Conclusion 3

**Formative**

Can we correct student difficulties with guided inquiry learning?

- Not sure

### Assessing Student Perceptions

**Summative**

What do students see as good about Guided Inquiry Learning?
Student Perception of Learning

• Student Assessment of Learning Gains

www.salgsite.org

1. HOW MUCH did the following aspects of the class HELP YOUR LEARNING?

1.1 The instructional approach taken in this class

1.2 How the class topics, activities, reading and assignments fit together

1.3 The pace of the class

1.4 Please comment on how the INSTRUCTIONAL APPROACH to this class helped your learning:

– Resources (online, textbook) (79%)
– Class Activities (60%)
– Instructional Approach (55%)

Intro. Class: Student Perception of Learning (N=172)

• How much did each of the following aspects of the class help your learning?

– the way in which the material was approached
– the pace at which we worked
– group work in class
– The mental stretch required of us
– the grading system used
– the feedback we received
– the quality of contact with the teacher
– working with peers outside of class

POGIL higher

Upper Level Class: Student Perception of Learning (N=25)

How much did each of the following aspects of the class help your learning?

– Levels
  Inquiry did as well often better as L-I and in intro course demonstrate problem solving.
– Topics
  Inquiry overall learned more at both levels

STUDENT PERCEPTIONS

Students want more explanation
Inquiry approach perceived as helpful to learning

Conclusion 4

• Majority of students think the approach helped them learn.

Conclusion Summary

LEARNING

– Levels
  Inquiry did as well often better as L-I and in intro course demonstrate problem solving.
– Topics
  Inquiry overall learned more at both levels

STUDENT PERCEPTIONS

Students want more explanation
Inquiry approach perceived as helpful to learning

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References


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.