



Implementation of Process-Oriented Guided Inquiry Learning in an Introductory Chemistry Course

Craig P. McClure and Joe L. March
The University of Alabama at Birmingham

Malinda M. Matney
The University of Michigan



Chemistry 100

Chemical Problem Solving

- Supplement for under-prepared students hoping to continue to General Chemistry (CH 115/117)
- Designed to help students succeed in General Chemistry Sequence
 - Basic Chemical Concepts
 - Mathematical Concepts
 - Particulate Nature of Chemistry
 - Problem-solving skills
- Class Size: 50 – 100 students/section (~300 per year)
- Lecture Format
- No Laboratory Component

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Observations about Chemistry 100

- 20% of students successfully completing CH100 (C or better) enroll in CH 115 the following term
- 50% continue in STEM majors, but don't take CH 115 the term following completion of CH 100
 - Improper placement in CH 100; Poor math skills (did not meet CH 115 math pre-req's)
 - Lack of self-perceived ability to "do science"
 - Perception of chemistry as a memorization topic
 - Loss of interest in Chemistry



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Research-Based Generalizations on Student Learning

Lillian C. McDermott

Am. J. Phys. 2001, 69, 1127-1137.

1. Facility in solving standard quantitative problems is not an adequate criterion for functional understanding.
2. Connections among concepts, formal representations, and the real world are often lacking after traditional instruction.
3. Certain conceptual difficulties are not overcome by traditional instruction. (Advanced study may not increase understanding of basic concepts.)
4. A coherent conceptual framework is not typically an outcome of traditional instruction.
5. Growth in reasoning ability often does not result from traditional instruction.
6. Teaching by telling is an ineffective mode of instruction for most students.



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Overcoming Barriers

- Cooperative learning environments were explored as a possible remedy to attrition
 - In general chemistry courses, students' confidence in learning chemistry has increased, as well as enrollment in later chemistry courses
 - Development of teamwork, problem-solving skills, and study skills transferred to more advanced courses
- These environments may help to address cultural learning differences in different groups as well



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Minority Group Differences

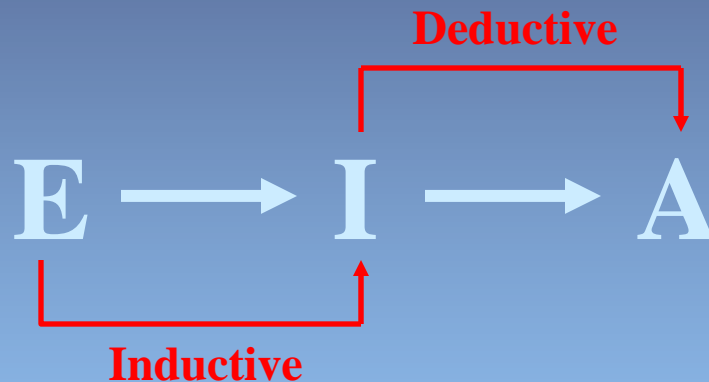
- Uri Treisman at the University of California at Berkeley studied success of students in calculus courses
 - Self-reliance which allowed African American students to gain acceptance into colleges prohibited them from forming study groups
 - Asian American students readily formed study groups, and succeeded in courses at a higher rate
- Significant improvement in academic motivation and class performance was seen for African American students after integration of cooperative academic activities into the mathematics curriculum

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Process-Oriented Guided Inquiry Learning (POGIL)

- Process – Oriented (utilizes learning cycle)



- Guided Inquiry
 - Activities are constructed to introduce topics and encourage exploration

POGIL Activity Model

The Model	The introduction of the subject of exploration for each activity. The particulate-level depiction, mathematical relationship, macroscale picture, narrative, data table, or other format which will yield information required in the activity.
Reviewing the Model	Simple questions to make sure that the student has understood the model, and is able to observe aspects of the model which are necessary for further exploration. Also reinforces chemical vocabulary and symbolic representations.
Exploring the Model	Questions which lead to concept invention (inductive reasoning) in determining the rules of the system, and asking questions about the model to emphasize key concepts. Also gives questions about similar problems, to start the deductive reasoning portion of the learning cycle.
Exercising Your Knowledge	Application of the concepts discovered in the Exploring the Model section of the activity. This portion models the deductive reasoning step of the learning cycle, asking the students to solve problems and further refine the concepts being explored.
Summarizing Your Thoughts	Concise summary of the discovered concepts communicated in the activity, reinforcement of new vocabulary, derivation and statement of rules discovered in the activity, and group self-assessment.



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Implementation

Students work in small groups on specially designed activities intended to develop mastery of both course content and key process skills.

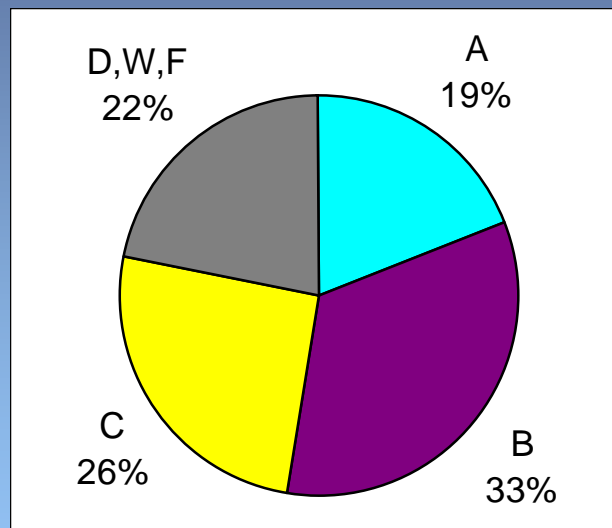
TARGETED PROCESSES

- Information Processing
- Problem Solving
- Teamwork
- Assessment
- Critical Thinking
- Communication
- Management

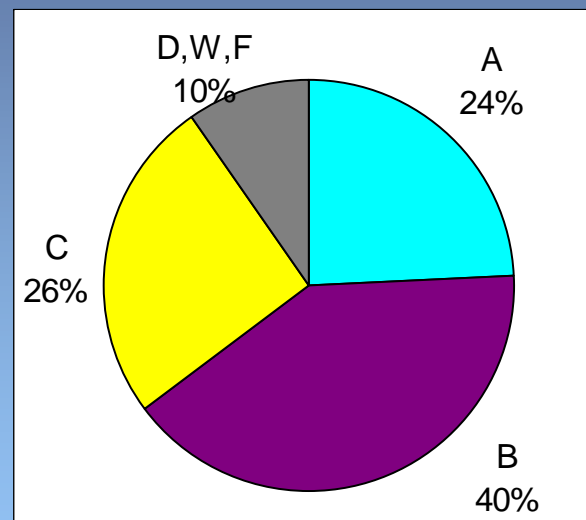
POGIL General Chemistry at Franklin & Marshall College

8 years of data (n = 905)

Lecture



POGIL



Data from classrooms of Moog, Farrell and Spencer

Chi-squared = 40.9 alpha < 0.005

Farrell, J.J.; Moog, R.S.; Spencer, J.N. *J. Chem. Educ.* 1999, 76, 570.

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POGIL Approach to CH 100

- Student-centered approach
 - For some students, serves as a repeat of material they have been previously exposed to, thus we will be presenting the material in a different manner
- Activities developed
 - 53 activities
 - 13 chapters
- Preliminary Edition tested
 - Full POGIL course Su 07
 - POGIL activities in Fa07, Sp 08, Su 08
- Activities under revision for First Edition



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Classroom Assessments

- 12-item Student Attitudes Survey, 6-step Likert-type survey
- Group Assessment of Logical Thinking (GALT), 12-item assessment of logical thinking skills, as applied to problems
- ACS California Chemistry Diagnostic Exam
- Courses involved:
 - Fall 2006, Lecture format (Instructors A & B)
 - Spring 2007, Lecture format with bi-weekly POGIL activities (Instructors A & B)
 - Summer 2007, POGIL format (Instructor C)
 - Fall 2007, POGIL format (Instructors A&B)

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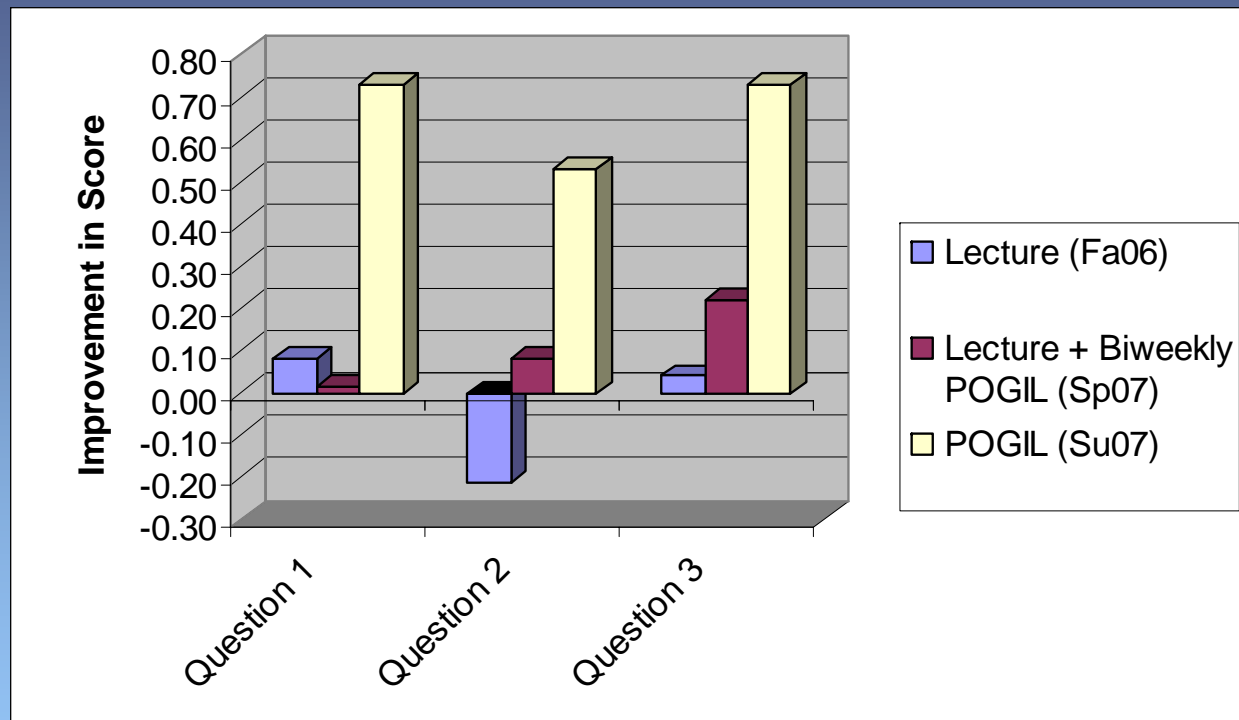
Student Attitudes Survey

- 1) I am confident in my ability to think about scientific questions
- 2) Knowing about chemistry helps me understand situations in my everyday life
- 3) I am comfortable taking chemistry courses
- 4) I am confident with my ability to complete math problems associated with chemistry
- 5) I prefer to study in groups with my peers
- 6) What I learn in my chemistry courses is applicable to my other courses
- 7) Problem solving in chemistry means matching problems with facts or equations and substituting values to get a number
- 8) I feel comfortable in talking about science with my peers
- 9) I am interested in chemistry
- 10) In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as givens
- 11) I learn more when working independently of others
- 12) I am confident in my ability to understand ideas presented in my chemistry courses

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Impact on Student Perceptions: Significant Assessment Differences



- 1. I am confident in my ability to think about scientific questions
- 2. Knowing about chemistry helps me understand situations in my everyday life
- 3. I am comfortable taking chemistry courses

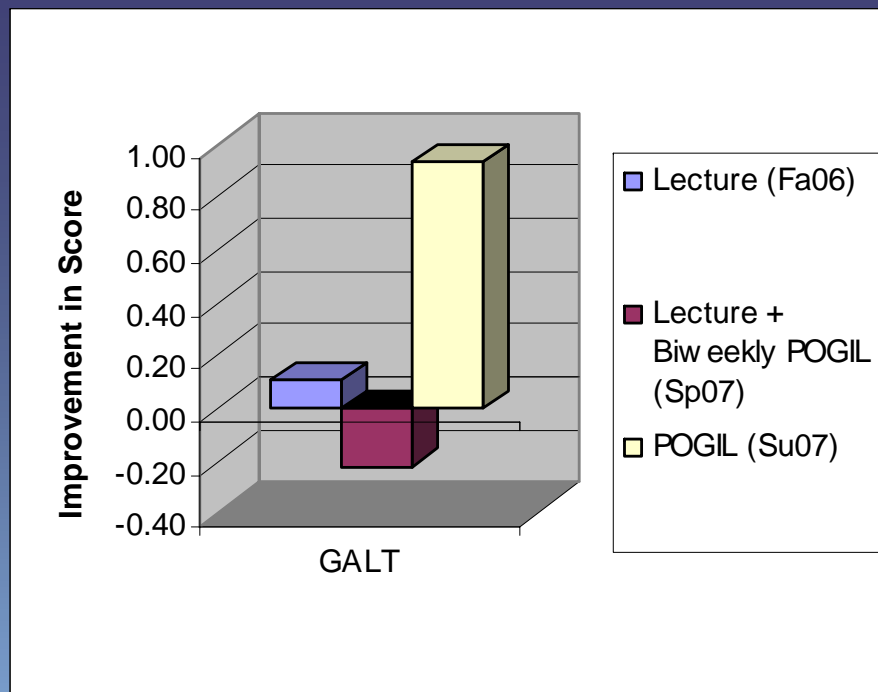
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Impact on Logical Thinking Skills

Change in GALT scores was monitored by subtracting pre-term from post-term scores

Students were categorized as low, medium, or high in their logical thinking skills



Low (0-7)

Medium (8-9)

High (10-12)

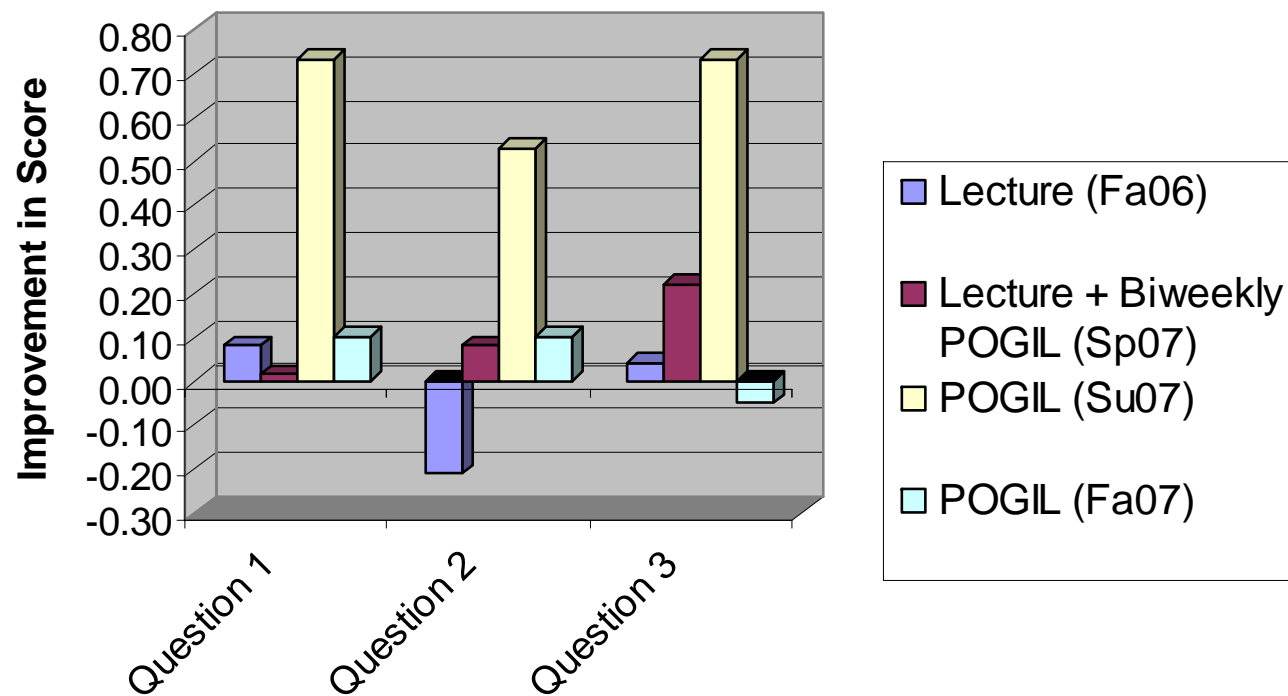
Lecture (Fa06)

Lecture + POGIL (Sp07)

POGIL (Su07)

	Low (0-7)		Medium (8-9)		High (10-12)	
	Number	Mean Change	Number	Mean Change	Number	Mean Change
Lecture (Fa06)	45	0.38	14	0.00	18	-1.17
Lecture + POGIL (Sp07)	28	0.18	13	-0.69	4	-1.50
POGIL (Su07)	9	1.11	3	1.33	3	0.00

Impact on Student Perceptions: Significant Assessment Differences



1. I am confident in my ability to think about scientific questions
2. Knowing about chemistry helps me understand situations in my everyday life
3. I am comfortable taking chemistry courses

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Why the differences in Student Attitudes?

- Class Size

- Summer '07 – 17 students
- Fall '07 – 38 and 99 students

- Instructors

- Summer '07 – Instructor involved in material development
- Fall '07 – Instructors not involved in material development

Continuing Assessment

•Current Course

•Instructors have opted to use $2/3$ of class meetings for lectures, and $1/3$ for POGIL activities

•Long-Term Assessment

- Students progressing to General Chemistry Sequence
- STEM Majors continuing beyond CH 100
- 5-year graduation rates
- Impact on under-represented groups in the sciences



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Interesting challenges in implementation

Information from instructor
interviews

Not unlike many faculty in transition, some common themes emerged

- Confusing teaching and lecturing
 - “We did so much group work that I didn’t have time to teach.”
- Being initially, or permanently, skeptical of new terminology
- Blaming the students for problems in the class
- Both see themselves as “old-school”
 - “Anti ‘touchy feely’.”
 - See innovations as being “pushed on us”



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What is a measure of success?

- Faculty focused on grades
 - Distanced from *themselves* actually looking at the difference
- They reported less satisfaction on student evaluations throughout course
 - However, there aren't companion evaluations from lecture based semesters

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POGIL can be a source of faculty development

- Clearly, some work in fundamentals of implementation needs to happen early
- As well, work in why this implementation is happening matters.
- A key difference in our faculty members was between one who was wholly resistant, and one who did his own internet search on POGIL to discover a bit more about the principles.

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After the big trial semester

- Each faculty member was allowed to return to his former teaching if he wanted.
- Both included some aspects of POGIL into some of his other methods.
 - Book
 - Some of the exercises
- They clearly reflected in various ways about the impact of this across all of their teaching

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Important observations about implementation

- Big lecture classes are more difficult, particularly without extra graduate student help.
- Telling the students “you are in an experimental class” gives students a negative attitude toward POGIL
 - A focus on “you are grasping more than the previous class” would increase engagement



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The logo for POGIL (Process Oriented Guided Inquiry Learning) features the word "POGIL" in a blue, serif font. The letters are partially enclosed by a red, curved shape that resembles a stylized 'P' or a partial circle.

Upcoming Workshops

Three-Day Advanced POGIL-IC Workshop at Stony Brook University:

Wednesday, June 18th, 2008 through Friday, June 20th

Three-Day Standard Workshop at Linfield College: (McMinnville, OR)

Friday, June 20th, 2008 through Sunday, June 22nd

Three-Day Standard Workshop at Washington College: (Chestertown, MD)

Tuesday, June 24th, 2008 through Thursday, June 26th

Three-Day Large Classroom Workshop at

Virginia Commonwealth University: (Richmond, VA)

Thursday, June 26th, 2008 through Saturday, June 28th

One-Day Introductory Workshop at NERM 2008: (Burlington, VT)

Saturday, June 28th, 2008, 9:00 AM - 4:00 PM

Three-Day Advanced Workshop at St. John Fisher College: (Rochester, NY)

Thursday, July 10th, 2008 through Saturday, July 12th

Three-Day Standard Workshop at Guilford College: (Greensboro, NC)

Friday, July 11th, 2008 through Sunday, July 13th

Three-Day Standard and Advanced Workshop at

University of Redlands: (Redlands, CA)

Monday, July 21st, 2008 through Wednesday, July 23rd

www.pogil.org

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