Teaching Mathematics using Inquiry

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Discovering the Art of Mathematics
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A New Vision

The Discovering the Art of Mathematics project provides a wealth of resources to support college faculty in teaching Mathematics for Liberal Arts, including a library of 11 inquiry-based learning books, professional development opportunities, and extensive teacher resources.

Read More »

In Their Own Words

Perhaps the best way to understand the depth and powerful impact of our project is to hear what the students have to say about their experiences.

Nic's Story

Hello, my name is Nicholas Taliceo and I am senior at Westfield State University. I’m a Mathematics major and I love it. I’ve had some amazing experiences — I’ve attended and presented at numerous conferences including the 2015 JMM conference in San Antonio, TX, and had the opportunity to experience undergraduate research, just to name a few. Interestingly, only a few years back, I would
“A wealth of research has provided clear evidence that active learning results in better student performance and retention than more traditional, passive forms of instruction alone.[...] In recognition of this, we call on institutions of higher education, mathematics departments and the mathematics faculty, public policy-makers, and funding agencies to invest time and resources to ensure that effective active learning is incorporated into post-secondary mathematics classrooms.”
What is IBL?
Experiencing an IBL classroom...

Determine all possible values generated by the expression

$$3a + 5b$$

when $a, b$ are non-negative whole numbers.

Discussion: Compare the conjectures and proofs that the different groups found.
Inquiry-based learning (IBL) is a powerful student-centered approach to learning that has many of the following characteristics ("Twin Pillars"): 

- The core of the class is problem solving (both in and out of class).
- The students are the primary drivers of class time.
  - sharing results, asking questions, and collaborating on solving problems

Students use reflection as well as active communication, both verbal and written, to assimilate new modes of thought, new learning strategies and new mathematical schema.
What is IBL?

The teacher’s role is decentralized.

- Minimal lecturing.
- Supporting students’ inquiry, instead of telling the students how to solve a problem.
- Structuring the activities and class time so that students are engaged mathematically and with each other is at the heart of IBL.
What is IBL?

- As we show the following pictures, what features of IBL do you see in these classrooms?
- What are students doing during class time? (What are they not doing?)
- What is the teacher doing during class time (or not)?
What is IBL? (Classroom A)
What is IBL?
What is IBL?
What is IBL?
What is IBL?
What is IBL?

- What features of IBL did you see in the pictures?
- What are students doing during class time? (What are they not doing?)
- What is the teacher doing during class time (or not)?
IBL Classroom Example A

- Students are provided carefully constructed sequences of investigations.
- The majority of class time is spent on student exploration motivated by these investigations.
- Students often work collaboratively in small groups.
- Students record patterns, data, conjectures, solutions and proofs in their notebooks as they work.
The teacher does not direct student work but rather inquires about progress, nurtures collaboration and coordinates groups’ sharing of their approaches.

Students synthesize their work – often outside of class - into complete solutions of the problems posed by the investigations.
Students are responsible for effectively communicating solutions that are supported by valid and convincing mathematical arguments. These solutions are a critical component of assessment.

Problem solving, reasoning and communication play important roles in all aspects of the course.
Video Example A

- Mathematics for Liberal Arts, $3a+5b$,
  [https://artofmathematics.org/media/video-461](https://artofmathematics.org/media/video-461)

- Mathematics for Liberal Arts, Rubik’s Cube
  [https://artofmathematics.org/media/video-488](https://artofmathematics.org/media/video-488)

- Calculus III: STEM majors, [https://artofmathematics.org/media/video-486](https://artofmathematics.org/media/video-486)

**Focus Questions:**

- *What do you notice the students doing?*

- *What do you notice the teacher doing, or not doing, to facilitate those student actions?*
DAoM Traveling Workshops

We offer workshops for faculty interested in our materials and our teaching techniques. We believe that our inquiry approach is applicable to teaching any mathematics class at any level. If you are interested two facilitators will travel to your institution to facilitate a 1-2 day workshop. Our workshops will help you:

- Experience what mathematical inquiry can feel like,

- Investigate particular content areas that might connect with your students,

- Understand and practice ways for creating a classroom environment where productive, safe, and deep mathematical inquiry can take place,

- Reflect on the interaction of teacher, student, investigations, mathematics, and inquiry materials in the classroom.
Resources

IBL Pedagogy:

- AIBL: www.inquirybasedlearning.org/playlist
- DAoM: www.artofmathematics.org/classroom

Course Materials:

- JIBLM: www.jiblm.org
- DAoM: www.artofmathematics.org/books
- Calculus: www.iblcalculus.com
- Linear Algebra: http://iola.math.vt.edu/

“Why IBL works”:

- https://www.artofmathematics.org/does-IBL-work
Thank you!

*We ask for your feedback to continue to refine our workshops.*
What is IBL? (Classroom B)
What is IBL?
What is IBL?
What is IBL?
What is IBL?

- As we show the following pictures, what features of IBL do you see in these classrooms?
- What are students doing during class time? (What are they not doing?)
- What is the teacher doing during class time (or not)?
Students are given problems to work on without knowing the answers, and are asked to bring in the next class period solutions to these problems.

The next class period, students sign up to present their solutions at the board. Students with the fewest presentations get priority.
IBL Classroom Example B

- Students write their solutions on the board simultaneously
- Each student presents their solutions to the class
- The audience is required to peer review the solution
The solution is either approved, fixed, or presented again.

The class then moves on similar to the other student presentations.
After the presentations, the instructor gives the class a task, such as working in small groups on the next batch of problems.

The instructor frequently gives mini lectures to summarize materials, emphasizing important points or sets up the next chunk of work.
Need for Resources

- Teaching via IBL has a significant start-up cost.

- There exist IBL-specific skills and practices that need to be learned for effective IBL instruction (Classroom management, Student buy-in, Assessment in an IBL class, Appropriate sequencing of problems and course materials)

- Week long summer workshops, see [www.inquirybasedlearning.org/workshops](http://www.inquirybasedlearning.org/workshops)
The following slides summarize some findings from Sandra Laursen et al’s study:

“From innovation to implementation: Multi-institution pedagogical reform in undergraduate mathematics,” Lighthouse Delta Conference 2013, Kiama, Australia.
Why IBL? Impact on students. (Sandra Laursen et al. IBL Study)
Why IBL? Impact on students. (Sandra Laursen IBL Study)
(Sandra Laursen IBL Study)
Other Resources: Why IBL?

- [www.inquirybasedlearning.org](http://www.inquirybasedlearning.org) (student testimonial on bottom of page)

- [https://www.artofmathematics.org/does-IBL-work](https://www.artofmathematics.org/does-IBL-work) (papers to read)