inquiry based learning
michigan mathematics

WHAT DO WE MEAN BY IBL?

- students learn through guided exploration with the help of experienced instructors.
- We engage the students, and emphasize discovery, analysis and investigation to deepen their understanding of the material and its applications.
- Students solve problems, conjecture, experiment, explore and create.

YIELDING:

- deep engagement in rich mathematical activities
- opportunities to collaborate with peers
- instructors who inquire into student thinking
- facilitation of equitable student engagement

IN SHORT: they practice all those wonderful skills and habits of mind that mathematicians engage in all the time. They gain in analytical thinking and communication skills, valuable in any occupation they decide to pursue.

Most amazing to me: the energy in IBL classrooms.

ENDORSED BY: CBMS, MAA, NRC

Inquiry Based Learning in mathematics at the University of Michigan has a long history, all the way back to the teaching of R. L. Wilder, E. Moise and P. Halmos in the 1950s and 60s.

Halmos famously summarized the idea of IBL in the phrase: “The best way to learn is to do; the worst way to teach is to talk.”

In the 1990s, Mort Brown, Pat Shure and later Karen Rhea established our reformed calculus, which incorporates ideas from inquiry based learning. Group work interchange with mini lectures in our calculus classes, letting the students immediately practice what they were exposed to in the lecture part of the class. Groups are typically 3,4 students. Class size is now low, 15 to 20. It used to be 32. Our Introductory Program has been hailed as truly successful in teaching calculus and its ideas to thousands of students every year.

Mort Brown also experimented with the IBL format in more advanced classes. This opened our path to a fuller IBL program.

Harry Lucas and the EAF (Educational Advancement Foundation) had supported IBL at a group of mostly smaller schools and U Texas. They decided in 2004 to expand the movement to math departments at major research universities and beyond. Thus started supporting the following five IBL Centers at:

- University of Chicago
- Harvard
- UC Santa Barbara
- University of Michigan
- University of Texas

GOALS

- implement IBL in our programs
- assess the feasibility and effects
- understand portability of the pedagogy and course materials.
- train junior mathematicians (graduate students and postdoctoral fellows) in IBL
- Outreach via our materials, IBL workshops, math circles and our website: https://sites.lsa.umich.edu/ibl/

The Centers developed somewhat different approaches to IBL. While we use several styles of IBL, most of our courses put the emphasis on student centered activities in class:

- groups of 3, 4 students work in class
- worksheets with a carefully built sequence of challenging problems
- instructor guides by visiting and monitoring the groups
- mini lectures on occasion, maybe to introduce or summarize
- students set the pace via their progress
- Students communicate both orally and in writing

However, we are open to different ways of teaching in IBL.

OUR MAIN GOALS:

- teach IBL courses at all levels
- develop materials for IBL courses
- train faculty, postdocs, grad students in IBL
- assessment of our courses, instructors and materials
- outreach via workshops, and sharing materials.

COURSES 6

20 IBL classes:

- freshmen to seniors, one grad class
- exploratory to math major to most demanding honors
- math-ed classes: future teachers learn to think through concepts and problems to become more confident of their knowledge and understanding (MKT - math knowledge for teachers)
- MATH 217 on linear algebra and introduction to proof and entry to the math major is our biggest IBL class with 400-500 students per year, taught in about 30 sections.hire 20-30 veterans each semester tutor current MATH 217 students in the art of proof writing, with IBL techniques
- MATH 412 on algebra: one of our latest conversions, 6 sections
- MATH 593: our first grad class on algebra, entry level
- Discussion sessions in graduate classes

COURSE MATERIALS

We have a large repository with IBL materials for the classes we teach, and are happy to provide access to instructors. Just contact me at spatzier@umich.edu.

175 - Introduction to Cryptology

176 - Explorations in Calculus

185 - Honors Calculus I

217 - Linear Algebra & Introduction to Proofs

285 - Honors Calculus III (IBL modules in some sections)

297 - Introduction to Analysis

310 - Choice and Chance

351 - Principles of Analysis

385 - Math for Elementary School Teachers

389 - Explorations in Mathematics - introduced by Mike Artin (MIT)

395 - Honors Analysis I (IBL modules)

396 - Honors Analysis II (IBL modules)

412 - Introduction to Modern Algebra

431 - Topics in Geometry for Teachers

486 - Concepts Basic to Secondary School Mathematics

489 - Math for Elementary & Middle School Teachers

490 - Introduction to Topology

497 - Topics in Elementary Mathematics

593 - Algebra I

INSTRUCTORS 8

FACULTY - strong buy in, 17 tenure eligible faculty and 8 lecturers have taught an IBL course, many multiple times, and quite a few have also developed materials.

POSTDOCTORAL FELLOWS

- 10 to 15 postdocs teach an IBL class per year, several multiple times. We graduate about 5 to 10 of them per year with significant IBL experience. Many others teach in our IBLish introductory program, and at least get exposed to the ideas.
- Postdocs most heavily involved in IBL are supported through teaching reductions. We hope to increase the available funding to be able to support more.
- Our postdocs in IBL have been successful obtaining jobs (e.g. Arizona, dePaul, Minnesota, Oberlin, Oklahoma, Tufts, UBC, UTexas, Virginia). Anecdotally, IBL seems to help.

GRADUATE STUDENTS - Currently, a few graduate students are involved as assistants to our math-ed IBL courses, and all via the IBLish introductory program.

UNDERGRADUATES - work as assistants. As such they help by coming to class, interacting with the groups similar to the main instructor.

TRAINING 9

TEACHER'S TRAINING: intense training week for our freshmen program. IBL Postdocs also participate in the IBL Workshop.

IBL WORKSHOPS - **local**: We hold a local 3-day long IBL workshop during our training week for both new IBL postdocs, and anyone else interested, local or not. This includes an introduction to IBL, hands on discussion after seeing video or actual IBL classes. This has been a transformative experience to some.
national: several national 4-day IBL workshops every year, organized by AIBL. They are very hands-on and intense.

SEMESTER SUPPORT: MATH 217 instructors get support from an IBL-experienced coordinator, and of course experiences fellow postdocs and faculty. Some of the new postdocs get training by co-teaching a class with an experienced instructor. Class visits by the coordinator.

Midterm assessment by a team from our School of Education under the lead of Vilmas Mesa, via class observations and focus group interviews, with fast feedback to the instructors.

Class observations by the IBL Director.

Three IBL lunches a semester - open to all: we discuss experiences, good and bad, approaches to problems, and other issues.

ASSESSMENT 10

Major assessment by over a three-year period (2007 -2010) by Sandra Laursen and her team at E&ER at the University of Colorado at Boulder, showing strong results for IBL. Assisted by Vilma Mesa at our School of Education.

- better understanding of concepts
- improved thinking and problem-solving skills, compared to traditional lecture based courses.
- confidence, attitude and persistence improved
- better collaboration better
- Best predictor of student gains: percentage of time instructors spent in class on student-centered activities
- No one was harmed by IBL, many benefitted, particularly female students.

OUTREACH

- Math Circles and Math Circles for Teachers
- Wolverine Pathways
- Michigan Math and Science Scholars summer program (MMSS)
- Laboratory of Geometry at Michigan
- Michigan wide IBL consortium

DONORS 11

Harry Lucas and EAF

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Van Loo Family gifts

University of Michigan

Words of Wisdom: it is very hard to get support from foundations