Inquiry Based Learning[4]

What is Inquiry Based Learning?

This is one of those obvious questions that is difficult to answer succinctly. The community of college-level math educators that has formed around the IBL label has intentionally taken a "big tent" approach to defining the term so that it's more of a philosophy than a specific teaching method. One large study of IBL in math courses [4] identifies two key features (sometimes called the "twin pillars"). If you're teaching an IBL course, your students should:

- actively engage with rich mathematical tasks during class, and
- collaborate and practice communicating mathematical ideas.

The details of how you do this will depend on what works best for you, your students, the course content, and other logistical considerations like the size of the class and the layout of the classroom.

One approach to IBL is to give students problem sets that have been carefully designed to lead students towards important ideas. The problems should generally be challenging but accessible for the students in the course. Class time can be spent in some mixture of having students work in small groups to solve these problems while you circulate, and having students present their solutions, followed by a class discussion of these solutions.

It is also possible to make small changes to a primarily lecture-style course to encourage students to engage with math during class. One simple, very effective strategy is known as think-pair-share. Give students a problem to work on in class, and then have them:

1. start by thinking about the problem on their own,
2. pair up with someone nearby to discuss their approach, and
3. share their ideas with the whole class

This approach gives students time to make sense of the problem, opportunities to learn more about what makes the problem interesting or difficult, and more reason to be interested and invested in ultimately seeing the problem solved.

For a more detailed account of what IBL is and some examples of implementation, see [1].

Why teach using IBL?

Students learn better from IBL. There is overwhelming evidence of this: a meta-study [2] found that active learning in STEM classes had a number of positive effects on student learning, and an extensive study of IBL [4] found that IBL math courses were particularly helpful in closing the achievement gap for women and for lower-performing students, especially when encountering IBL early in their mathematics career.

This makes sense. People learn new skills, whether it's playing a musical instrument, competing in a sport, or doing math, by practicing them, so we should prioritize giving our students opportunities to practice math while we're there to provide guidance.

You get to watch your students doing mathematics. This is an obvious consequence of having students do math during class, but it is worth emphasizing because witnessing this is one of the joys of teaching an IBL class. You know that moment that happens sometimes in office hours, when a student finally makes sense of a topic they've been struggling with? In an IBL classroom, you get to see that happening in class, over and over. You get to listen as your students have genuine, deep conversations around mathematical ideas.

You gain a better understanding of what your students know. When lecturing, it's easy to believe that, since something was said and no one asked any questions, the students must have understood it. When you spend class listening to your students discuss math, you gain a much better sense of exactly what they've understood and what they're still working through.

Your students gain a better understanding of the practice of mathematics. Math lectures can give students mistaken beliefs about what it means to do math. Solutions immediately follow problems, with no sense of the time and effort it took people to first come up with the necessary ideas. Theorem statements and proofs arrive fully formed, without errors or dead ends.

In an IBL course, instructors still provide structure to guide students in the right direction, but you have the opportunity to show them that solving interesting mathematical problems takes time, that mistakes can provide valuable insight, that promising beginnings can lead to dead ends that can themselves lead to new insights. By emphasizing the notion of *productive struggle*, you can teach your students to persevere and become better problem-solvers alongside teaching them the course content.

Some history

Someone whose view of IBL was formed in the early 2000s might describe it very differently from the way I have. Here is some context; a more detailed exploration of this story can be found in [3].

There is a particular segment of the IBL community whose origins are intertwined with the Educational Advancement Foundation (EAF). The EAF has provided extensive support for IBL workshops, centers, and other initiatives that played an important role in training many mathematicians, including myself, in IBL methods. But the EAF was created in particular to spread awareness of

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the "Moore Method," which is a very specific approach to teaching developed by R. L. Moore, and this means Moore Method played a large role in discussions of IBL when the EAF first began funding IBL programs. Ultimately, though, the larger IBL community has chosen to pull away from this association with Moore, for a number of reasons: his approach forbade collaboration; instructors didn't want the limitations that come with focusing on a single method developed by a single person; and Moore's documented history of racism, sexism, and anti-Semitism was an impediment to the goals of inclusion and equity that the IBL community holds.

This community as it currently exists includes people who came to IBL from many origins, and is interested in nuanced conversations that value a variety of experiences and perspectives, with an emphasis on thinking about what we can do to make sure all students have positive mathematical experiences. If this sounds like a group you'd like to be a part of, then I hope you'll come join the conversation.

How do I learn to teach this way?

You don't have to radically change everything at once. You can start by mixing think-pair-share problems into your lecture, or spending one day a week with students working on problems in groups and presenting ideas, and lecturing other days. Any way you can find to get your students actively engaging with the material in class will be good for them.

Whether you make large- or small-scale changes, here are some additional things you can do.

Find a community. Taking a student-centered approach to teaching means relinquishing some control over what happens in class, and that can lead to a lot more variation in what difficulties you encounter. You'll benefit from having a network of experienced instructors to go to for support and advice. You can find such a network by attending a workshop, or by becoming involved in the organizations listed below.

Find course notes. One of the hardest parts of teaching an IBL course is developing the materials that will lead students in the direction you want, scaffolded in such a way that students are challenged but ultimately able to succeed. *Journal of Inquiry-Based Learning in Mathematics* (`jiblm.org`) has peer-reviewed notes for many courses, and if you ask around you will find that IBL instructors are usually happy to share what they've tried.

Watch someone teach an IBL course. If you know someone teaching a course with IBL elements, ask to observe their class. Seeing IBL in action can give you a much better understanding of how it works.

Attend a workshop. There are a number of workshops, both stand-alone and attached to various conferences, intended to help instructors prepare to teach a course in an IBL style. See the organizations below for some options. Participating in these helps you get started and gives you a community of people to continue talking to.

Some IBL organizations:

This is by no means an exhaustive list, but gives you some places to start.

Academy of Inquiry-Based Learning: `www.inquirybasedlearning.org`

IBL SIGMAA: `sigmaa.maa.org/ibl`

Mathematics Learning by Inquiry: `www.mathlearningbyinquiry.org`

References

[1] Ernst DC, Hodge A, Yoshinobu S. What is Inquiry-Based Learning? *Notices Amer. Soc.*, **64**(6), 2017.

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[3] Haberler Z, Laursen SL, Hayward CN. What's in a name? Framing struggles of a mathematics education reform community. *Int J Math Educ Sci Tech*, **4**(3):415–441, 2018.

[4] Laursen S, Hassi M, Kogan M, Hunter A, Weston T. *Evaluation of the IBL Mathematics Project: Student and instructor outcomes of inquiry-based learning in college mathematics*. Colorado University, 2011.

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Credits

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