Collaborative Research: Research, Dissemination, and Faculty Development of Inquiry-Based Learning (IBL) Methods in the Teaching and Learning of Mathematics

Cumulative Evaluation Report: 2010-2013

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Executive Summary

This report details findings from the evaluation of four annual workshops hosted at the IBL Centers[1] from 2010 to 2013 and supported by the National Science Foundation. The workshops were designed to introduce participants to inquiry-based learning (IBL) instruction and show them how to teach a course that has been fully developed in that style. Each intensive, four- or five-day workshop had its own unique schedule, but they all included similar activities such as talks from invited speakers and discussion panels. Participants at the different workshops engaged in activities such as watching videos, reading and discussing research articles, listening to plenary talks, participating in panel discussions with experienced IBL instructors, observing and discussing IBL classes, and developing IBL materials.

As evaluators for the IBL Centers' workshops, we gathered data to identify who participated, what they did or did not gain from participation, and their perceptions and advice about workshop activities and logistics. To do so, we conducted online pre-workshop surveys, in-person post-workshop surveys, and online follow-up surveys one academic year after the workshop with each workshop cohort.[2] Generally, response rates were high. Of the 167 participants at the four workshops, 87% completed the pre-surveys, 90% completed the post-surveys, and 67% completed the one-year follow-up surveys. Using anonymous identifiers to match individuals' surveys from different times, we were able to successfully match 80% of post-workshop surveys and 72% of follow-up surveys to the pre-workshop surveys. Additionally, we conducted follow-up interviews with a subset of 16 participants from the first two workshops (2010 and 2011).

Participants at the workshop were fairly diverse; females and minorities were represented in proportion to mathematics faculty as a whole. Participants represented a variety of career stages and lengths of teaching experience, including new, untenured faculty as well as tenured faculty with more than 20 years of experience. Participants came from different types of institutions, mainly four-year colleges and Ph.D.-granting research universities. About 13% taught at Minority-Serving Institutions. About half of participants had no prior experience with IBL as instructors or as students. However, participants expressed high motivation to use IBL and strong beliefs in its effectiveness prior to the workshop. Hence, they entered as already motivated and interested participants.

[1] At the Universities of Chicago, Michigan, Texas at Austin, and California-Santa Barbara.
[2] One-year follow-up surveys for the 2013 cohort will not be collected until Fall 2014.

Overall, almost all participants rated the overall quality of the workshop, as well as the logistics, as 'good' or 'excellent.' Quality ratings were significantly higher for the 2010 workshop than the other three, and logistics ratings were significantly lower for the 2011 workshop than the other three. However, all four workshops seemed to successfully meet their goals of introducing participants to IBL and showing them how to implement IBL methods in their own courses: following the workshop, participants reported greater knowledge about IBL and skill in implementing it, as well as increased motivation and belief in its effectiveness. One year later, knowledge and skill remained at the post-workshop levels. Belief in the effectiveness of IBL dropped slightly, though remained higher than pre-workshop levels, and motivation to use IBL returned to pre-workshop levels. The post-workshop spike in motivation may be instrumental in getting participants to start implementing IBL in their own classrooms**.**

Implementation of IBL

Many participants from the 2010, 2011, and 2012 workshops reported implementing IBL in their own courses. (Follow-up information for the 2013 workshop will be collected in Fall 2014.) At least 58% of participants used some IBL techniques in the year following the workshop, including 29% that taught a 'full' IBL course and 29% that implemented some IBL methods along with traditional methods. However, that is a conservative estimate, counting non-responders as non-implementers. In comparison, of those that responded, 88% reported using at least some IBL methods. These implementation rates are high, especially given participants' comments on the extensive amount of time required to develop an IBL course.

Reported implementation rates were higher for the 2012 workshop than the 2010 and 2011 workshops. This may be related to follow-up activities; the 2012 workshop is the only one of the three that has had consistent follow-up engagement of participants, largely through an e-mail listserv. On the listserv, which includes both participants and workshop facilitators, members checked in and cheered each other on, as well as shared ideas and posed and responded to difficulties individual instructors were facing with implementing IBL in their classrooms. In the year following that workshop, 62% of workshop attendees, and 65% of all list members were active on the list.

In addition to their self-categorized implementation level, participants reported the frequency with which they used different instructional strategies on both pre-workshop and one-year follow-up surveys. Comparisons of individuals' responses revealed *decreased frequencies* of:

- Instructors lecturing
- Instructors solving problems at the board

Participants also indicated *increased frequencies* of:

- Student-led whole class discussions
- Students discussing in small groups
- Students presenting problems or proofs

Overall, these changes are consistent with inquiry-based learning and a shift from instructor-centered activities to student-centered activities. Comparisons on non-IBL specific techniques, such as computer-assisted learning or instructors asking conceptual questions, did not change significantly. Moreover, changes in teaching strategies seemed to be sensitive to the presentation of IBL at the workshops. Some participants were presented with a Modified Moore Method representation of IBL, characterized by student

presentations and rigorous discussion, while other were presented with a group work-based representation of IBL. Participants who were presented with a Modified Moore Method representation of IBL reported *greater increases* in frequency of student presentations than those that were presented with group work-based IBL.

Further, in interviews conducted with a subset of participants from the 2010 and 2011 workshops, participants provided more detail about their classroom practices. While those who classified themselves as "full" IBL implementers described using the Modified Moore Method almost exclusively, "partial" IBL implementers revealed a broad spectrum of practices. This included some who used IBL techniques for part of each class, some who split their courses between lecture days and IBL days, and some who started with lecture but gradually changed to full IBL throughout the course of the semester. Coming to see IBL as a broad "spectrum" of practices seemed to be important in helping participants to become implementers, as gradual steps seemed more feasible than completely redesigning and entire course. In fact, one participant explained that, "The Moore Method is something that I don't feel comfortable applying. But, feeling like I can pick and choose aspects of [IBL], and find something on the spectrum that I feel comfortable with, was empowering." We discuss other factors affecting implementation in the full report.

Implementation Barriers

On post-workshop surveys, participants commented on the concerns that they still had with implementing IBL. The three most frequent concerns were:

- IBL's in-depth approach makes it difficult to cover enough material
- Student buy-in to new IBL techniques
- Lack of instructor skill to implement IBL

These three biggest concerns were important topics discussed during the workshops. While facilitators did share strategies for dealing with coverage and buy-in issues directly, these concerns also likely dissipate over time as instructors practice and gain skill with IBL.

In addition to these survey responses, interview participants provided detailed information about the factors that affected their implementation of IBL. Participants experienced actual barriers, the biggest of which were student resistance, instructors' fears that they would not be successful in using IBL, and lower student evaluations. Participants were largely able to overcome these barriers, as 15 of the 16 interviewees had implemented IBL to some degree.

Implementation Supports

Supports that participants identified may have helped them to overcome these barriers, and commonly included:

- Departmental support
- Additional IBL-related professional activities
- Mentors or IBL colleagues

Departmental support was identified most frequently in the interviews, and in fact, on follow-up surveys, 85% to 90% of participants reported at least moderate support from each of three distinct but important groups: departmental colleagues, department chairs, and provosts or deans. Although departmental resistance was mentioned relatively commonly on pre-workshop surveys and in person during the workshops, most participants in fact reported feeling supported when they actually tried to implement IBL.

Interviewees also identified the IBL community as supportive. This included other IBL-related professional activities such as Project NExT, the 'Legacy of R.L. Moore' conference,

colleagues using IBL, and IBL-focused events at large professional meetings. Three of the workshop facilitators, Mike Starbird, Carol Schumacher, and Stan Yoshinobu, were named as particularly helpful. Interviewees cited talks these individuals gave, books they wrote, and personal conversations and mentoring as valuable developmental activities.

Implementation Considerations

In addition to barriers and supports, interviewees also commented on considerations they made when implementing IBL. Rather than being barriers, or actual problems they encountered, these comments focused on issues instructors thoughtfully addressed in order to implement successfully. Thus they may provide the best picture of what topics workshops should cover to be most useful. Indeed, many of these topics were addressed in the workshops, including:

- IBL-appropriate materials
- Changing of instructors' role
- Techniques for student participations and assessment
- Student buy-in and marketing
- Situational factors (class level, class size, student audience, physical space)

The two most mentioned considerations dealt with two big changes instructors needed to make, IBL appropriate course materials, and the changing role of the instructor. Whereas most traditional instructional materials are designed to show coherent solutions or proofs, IBL materials instead aim to set up explorations where students can successfully make sense of the material by discovering solutions or proofs themselves. Instructors sometimes used already-created IBL materials, often modifying them for their own purposes, or developed them from scratch. Just as materials were designed to encourage students to do the sense-making for themselves, instructors' roles shifted from presenters of knowledge to facilitators helping students to construct their own knowledge. These two considerations were addressed in the workshops, as the 2010 and 2012 workshops gave participants extensive time to develop IBL materials and all workshops addressed the shift in instructors' roles through a mix of invited talks, discussions, videos, and in-person observations.

As instructors' roles shifted and students became more active participants, instructors developed techniques to support the new environment. Instructors brought out student participation partially by providing incentives. For many, this included making it part of their grade, but others also had methods to promote equitable student participation such as computer-generated 'priority trackers' to keep track of who had presented.

Since these changes were new for many students, instructors were careful to explain the rationale for using IBL techniques to their students. It was important for instructors to get student buy-in through this 'marketing' at the beginning of the course, but also to maintain morale throughout the term.

While these most frequent considerations all relate to classrooms where instructors implemented IBL techniques, instructors also commented on situational factors that determined whether or not they would try implementing IBL. They considered things like the number of students in the class, the level of the class, the student audience, and the physical space available. There was no general consensus as to what was best for each, as interviewees used IBL in a variety of settings. However, they did affect the shape of IBL courses. For example, large classes could use group work instead of individual

presentations, while theater-style seating made group work difficult but may have been fine for presentations.

Conclusions

Overall, the workshops served a diverse set of participants who were highly satisfied with the quality and logistics. Though participants entered the workshops already holding strong beliefs in the effectiveness of inquiry-based learning, they reported significantly stronger beliefs after the workshops. Participants also reported significant increases in their knowledge about IBL and skill in implementing IBL.

Despite expressing many concerns, most participants reported implementing IBL practices in their own classroom during the year following the workshop, and many planned to use IBL techniques in future classes as well. Changes in reported teaching practices supported this, and indicated a shift from instructor-centered lecture models to more active student participation including group work, presentations, and discussions.

Participant interviews supported self-reported implementation results and provided more detailed information about classroom practices. Participants identified some barriers to implementing IBL, but by thoughtfully designing their courses, most reported successfully using IBL methods in the year following the workshops they had attended. Participants spoke about how gaining understanding of the spectrum of IBL techniques made IBL more accessible, and how experienced practitioners from the workshops served as valuable mentors.

Additionally, survey findings, along with interview participants' reflections on their own development, reveal common themes that future workshops can use to help participants successfully adopt IBL techniques, including:

- Exposure to a broad 'spectrum' of IBL varieties, with discussions about the new roles for instructors and students
- Time and resources for developing IBL-appropriate course materials
- Specific strategies to deal with some of the major concerns of IBL implementers (i.e. student buy-in/resistance, marketing, coverage, techniques for participation, etc.)
- Ongoing support and inclusion in the broader community of IBL practitioners

Taken together, all evidence indicates that these workshops have helped participants make the transition from being observers interested in IBL to becoming IBL practitioners. The findings have also helped to reveal important factors for instructors beginning to make the change from instructor-centered methods to student-centered and inquiry-based classrooms, and how workshop facilitators can support them in making the transition.

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