Collaborative Research: PROfessional Development and Uptake through Collaborative Teams (PRODUCT) Supporting Inquiry Based Learning in Undergraduate Mathematics

Synthesis and Study Methods: Final Version
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This document provides an overview of the PRODUCT workshop evaluation study design and findings. Its initial function was to describe the methods and data sources for workshop reports throughout the PRODUCT project; This information was periodically updated as the methods evolved and is included at the end of the report. In addition, across the multi-year duration of the project, we came to find it helpful to synthesize data from several individual workshops offered each year in order to capture key findings and general lessons learned. By tracking insights gained from the evidence in this way, we can thus see connections between the formative feedback cycle and the summative results that reflect whether and how such feedback was incorporated. In large part, the document reflects substantial learning and improvements to practice made by the project leaders and team members in response to evaluation findings. The document was updated several times throughout the project period.

Workshop Design

These workshops use the model developed during the previous SPIGOT workshop series (Hayward & Laursen, 2016; Yoshinobu et al., 2021). Each workshop is four days long and includes four main types of sessions: (1) Reading sessions - where participants read and discuss research about IBL and active learning, (2) Video sessions - where participants watch and analyze videos of IBL classes, (3) Nuts & Bolts sessions - where participants discuss the skills of structuring and running an IBL class, and (4) Course Content sessions - where participants work in small groups, along with staff guidance, to develop materials to use in their own courses. Additionally, each workshop usually features a panel discussion where participants can pose questions to the workshop staff, as well as two plenary talks, which vary by workshop but may feature course overviews, student panels, or inquiry-based math activities, for example. Teams of four or five facilitators run each workshop. Each facilitator takes on the lead role for running one type of session, but all are available throughout to discuss and answer participant questions. Prior to the workshop, participants prepare by reading articles and viewing online videos.

Annual Takeaways

The project uses a data-driven approach: as we evaluate each workshop, we learn new things and workshop leaders use these findings to make small adjustments to the design. Feedback on each workshop is reported in individual workshop reports on the survey and observation data; here we synthesize findings over multiple workshops and identify cumulative lessons learned across multiple years of the PRODUCT project.

2016 Workshops

The PRODUCT team offered two workshops in 2016. They were held back to back at Cal Poly and run by two different teams of facilitators. Both workshops had largely positive feedback, and facilitators felt comfortable running the sessions and delivering workshop content. However, we did gain some useful insights about how to best support new workshop facilitators.

- Logistics: A scheduling conflict at the first PRODUCT workshop this year resulted in the use of a different workshop room from past offerings. Acoustics and heat regulation in this room were poorer than the usual room, and some participants found this to be an obstacle. This should serve as a reminder for future workshops that planning and scheduling can never be started too early, and good backup plans are sometimes necessary.
- Unexpected challenges: At 4 of the 6 workshops offered through SPIGOT/PRODUCT to date, large, unexpected challenges have arisen, such as participant illnesses and travel interruptions. While these are difficult to plan for, they highlight the need for local staff who can efficiently address these concerns. In the past, AIBL staff members have dealt with these issues, allowing facilitators to focus on running the workshop. Leaders of future workshop may want to consider how to best manage personnel resources so that an individual with knowledge of local resources is available to help. This may mean strategically pairing facilitators or co-planning so that if needed, sessions can run smoothly without a local facilitator. It may also help to enlist local support staff.
- Deliberate modeling: Past evaluation has shown that modeling of good classroom strategies during the workshops helps to demonstrate IBL strategies and helps the workshops to run smoothly. Facilitators should work to model strategies for picking groups, facilitating discussions, and eliciting participation. Moreover, these strategies should be deliberately revealed to participants either before or after use, with some discussion about what the facilitator hoped to achieve through its use. For example, facilitators should be careful to not jump in to discussions too soon, and instead allow participants time to discuss ideas with each other. The facilitators could then comment about how they had demonstrated patience and wait time, and point out what good ideas arose during the discussion because of it.
- Scaffolding: When running a workshop for the first time, it is hard to see the big picture of how sessions connect and support each other. Planning together as a workshop team, rather than only separately by sessions, may help facilitators to see this big picture. It is important that the role of each session and how it fits into the model is communicated to participants strongly and explicitly at the beginning of each session. For example, the purpose of the Reading Sessions is often least obvious to participants who feel they are already 'bought in' to IBL and don't see the true purpose until they return to their home institutions and need to support their pedagogical choices against doubts from skeptical colleagues.
- Reading Sessions: Reading Sessions continue to be a challenge. In addition to the suggestion above regarding strong messaging, the PRODUCT team should also work to develop a standard set of activities for the Reading Sessions. In our experience, interpreting and making use of mathematics education research requires a different mindset and set of skills than needed for mathematics research. Participants may need more guidance in the Reading Sessions than they are currently getting. It seems that activities that focus on the goal of using research to support

the use of IBL (e.g. role playing a discussion with a skeptical colleague) tend to be better received than more open-ended activities of using the research to attempt to answer participants' questions.

2016 – Follow up reports (August 2018)

Overall, outcomes from the first set of workshops are similar in terms of implementation rates and changes in attitudes and beliefs about IBL. This is a promising outcome for these teams leading their first workshops. However, one difference between these first PRODUCT workshops and earlier SPIGOT workshops is the lower engagement in terms of follow-up survey response rates (60-70% vs. 75-80%) and activity on the listserv. Because of lower response rates across all 3 surveys, we were only able to match 57% of responses for each workshop rather than 70-80% as in previous workshops. This resulted in a loss of statistical power for analysis. So, outcomes such as changes in teaching practices may actually be better than we are statistically able to claim.

Low activity on the listserv also makes it difficult to gauge implementation rates. With past workshops, survey responses were the main source of implementation data. Occasionally, we could also show 1 or 2 other non-respondents had implemented IBL via messages they sent on the listserv. While surveys were anonymous and we couldn't cross-reference one-to-one by individual, we could add implementation outcomes for survey non-respondents based on their messages from the listserv. We could be fairly confident they were implementing IBL because participants tended to send a number of messages describing their IBL-style classrooms.

However, with fewer messages overall for this cohort, implementation data from the listserv is not a very reliable data source. In some cases, the only evidence we had was a quick check in saying something to the effect of "I'm using IBL in my (course name) class" without much additional detail to verify that claim. So, low survey response rates mean we have to rely more heavily on listserv messages, but low activity means that listserv message are not a very good data source. While overall implementation rates may seem similar to those from prior years, it is a much less confident measure.

Low listserv activity makes it a less reliable source of outcome data and may also be related to lower survey response rates. So, while low activity affects our ability to measure workshop outcomes, it also means participants do not have this useful resource to draw from. Our prior research has shown that a listserv can in fact provide the type of support participants need to successfully implement IBL, including group trouble-shooting to improve IBL courses (Hayward & Laursen, 2018). For the 2016 workshops, activity was quite low and participants' ratings of the usefulness of the listserv were lower than for previous workshops. In the past, 30-40% of participants rated the listserv as a "great help." For the 2016 workshops, only 6% and 18%, respectively, rated it as a "great help." The listserv is a crucial feature of the workshop model. Keeping participants engaged may contribute to higher implementation rates and possibly more successful implementations.

2017 Workshops

The PRODUCT team offered three workshops in 2017. The first, workshop 3, was held at DePaul University with mainly returning facilitators. The second, workshop 4, was held at Cal Poly, with largely new facilitators. The final workshop, number 5, was held at Nazareth College and again run by the

Upstate New York IBL team. All workshops had largely positive feedback, and facilitators felt comfortable running the sessions and delivering workshop content. We saw some improvements over last year's first-time offerings:

- Logistics: Overall, logistics went well at all three workshops this year. Outcomes were on par with other prior workshops using campus housing and food services—not spectacular, but acceptable and appreciated by most people. Having a pro-active, local support person seemed to be particularly helpful for the DePaul team. For future workshops, it will be a good idea to consolidate pre-workshop communication so that participants can have a single email to refer back to for important information.
- Unexpected challenges: As usual, there were challenging incidents, mostly related to travel. The workshop at Nazareth College used smaller regional airports (Buffalo, Rochester). The related travel snafus were similar to what we've experienced flying through San Luis Obispo in prior years, but the team handled them well. This underscores the importance of having a local organizer who is able to handle these situations.
- Deliberate modeling: Facilitators at all three workshops intentionally modeled various IBL strategies as the facilitated workshop sessions, and participants commented on how helpful this was. In some cases, facilitators kept a running list of the strategies they used on large pieces of chart paper. This was most useful when it was an overt, visible reminder placed towards the front of the room. This would be a good practice to continue for future workshops.
- Scaffolding: Scaffolding within workshop strands seemed much improved this year. For the most part, sessions had a clear purpose and activity. However, there were a few comments that the goals of individual sessions could be clearer, and some evidence that it takes a while for pieces to come together for participants, which suggests that scaffolding across strands could be further strengthened. It seems that facilitators are aware of these areas and have already begun making plans for how to improve framing for next year. We emphasize that clear understanding of the workshop components and their linkages—both within strands and across them—is important for facilitators and participants alike.
- Reading sessions: Four facilitators experienced with the Reading sessions worked throughout the spring to redesign the Reading sessions. Session 1 focused on the evidence for IBL, session 2 on using literature to inquire into student thinking, and Session 3 on issues related to diversity and inclusion in IBL classrooms. Overall, participant feedback this year was quite positive about the redesign of these sessions. The one minor tweak suggested by a handful of participants was that the particular reading for Session 2, Trigueros and Jacobs's *On Developing a Rich Conception of Variable*, was not the best article for the activity. However, participants liked the focus of using the literature to inquire into student thinking and learning. There are many examples of this type of work coming out of the Research on Undergraduate Mathematics Education (RUME) community that could be good options. For example, Kung and Speer's 2013 paper, *Do They Really Get It? Evaluating Evidence of Student Understanding of Power Series,* provides an example of how instructors can use student discourse and work to understand student thinking.

Additionally, we gained some new insights in this second year of workshops, both from analyzing participant feedback and discussing this feedback with the facilitator teams:

- Coherence: Coherence across multiple workshop strands was improved at all three workshops this year. On the whole, there were fewer comments about sessions being unclear or aimless. Some evidence indicated that more synthesis would be helpful. Two approaches that could be helpful are (1) using "Teaching As A System" as an overarching framework to tie sessions together or (2) re-labeling the schedule around particular themes that communicate the purpose of different sessions to participants, not just by strands related to facilitator roles, to help make the big ideas more obvious. For example, switching from nondescript titles like "Video Session 5" or "Nuts & Bolts 3" to topic-focused titles such as "Video: Student Buy-in" or "Nuts & Bolts: Buy-in Plans" would help to increase coherence and draw out the themes across sessions. Participants would benefit from understanding how each session contributes to the workshop's overall learning goals; for this to occur, facilitators must themselves deeply understand the connections and take active steps to make these linkages for participants. Thus it's important for facilitators to cross-reference ideas across sessions and reinforce the arcs of big ideas and principles throughout the week. This is especially important given the 'big tent' version of IBL that is presented: because instructors are not using specific curricula or methods, the principles of IBL are key take-aways for making judgments for their own courses.
- Planning: Related to the issue of coherence, we recommend that future teams engage in deliberate planning to identify workshop themes and cross-connections and plan how they will emphasize these. One strategy was creating an annotated schedule where themes, takeaways or learning goals, and participant activities were identified for each session. This helped to ensure that activities were focused and activities varied so that it was easier for participants to remain highly engaged throughout the entire workshop.
- Facilitator buy-in and growth: Just as varying activities helps participants to remain engaged, switching roles may help facilitators to remain more engaged. Now that facilitators have experience with the existing workshop model and their current roles, there are opportunities to broaden their expertise by switching roles, and to develop more ownership over the workshop model by modifying existing sessions. In the future, we should create additional opportunities for facilitators to take on diverse responsibilities and have input on the continued evolution of the workshops.
- Diversity: There were comments related to diversity in terms of instructor backgrounds and contexts represented by facilitators and workshop examples. For example, there is a preponderance of videos of white, male instructors using presentation-style IBL in similar institutions. Some participants felt that this did not relate to their own experiences as faculty of color and as women, many also early in their IBL and teaching careers. Similar issues have been raised in the past; these concerns are not unique but were highlighted perhaps due to participant demographics at particular workshops.
- Modeling: In previous workshops, activities where participants experience IBL as students have not always gone well. This year, facilitators ran multiple plenary sessions of this type that were well received. One suggestion was to make the opening session experiential. This is analogous to

variations in Day One activities; some instructors start by going through a syllabus or teacher-led buy-in activity, whereas others immediately set the expectation that students will work collaboratively by having them work on mathematics. We've learned that experiential activities tend to be more successful when facilitators are careful in framing the activities and explaining what participants are meant to gain from them. In debriefing an activity, it's also important to be explicit about when participants should assume teacher or student roles, and to recognize the potential awkwardness of this due to the power dynamics it may create between peers – and facilitators should reiterate this in case some participants miss it the first time through! Participants usually really enjoy digging into mathematical tasks together, but such tasks should be followed with discussion to help participants draw meaning from both student and teacher experiences in IBL classrooms. Recent comments from the two-day workshop in New York also point to the importance of choosing a mathematical task that is interesting but comfortable for everyone.

Switching up teams and roles could benefit many of these areas, with potential to create more diverse teams, inspire teams to do deliberate planning, and provide new opportunities for facilitators. It may also be beneficial to recruit and develop new facilitators, as this would help to achieve these same goals and would create more talented facilitators. By this point, most of the facilitators are experienced instructors and are also gaining experience as faculty developers. They could serve as mentors to newly recruited, less experienced facilitators. Experienced 'front office' facilitators could also rotate in as facilitation team members. They could serve as valuable role models to all facilitators, especially for those who have not had an opportunity to witness these highly-experienced facilitators in action. As an added bonus, it would provide opportunities for facilitators to observe somebody else run a session of their strand, so that they could focus on big-picture connections that can easily take a back seat to in-the-moment facilitation concerns.

Taken together, there are two areas that need to be addressed for next year:

- Diversity could be addressed through some deliberate practice and brainstorming at the Developer meeting, and through getting more diverse examples of instructors, courses, and styles for video sessions. Though video examples are difficult to collect, it is necessary. The teams had ideas of readily available video examples that could be drawn upon to redesign the Video strand so it meets the needs of all participants. Because of the interplay of video and diversity, outside funding to expand the video collection should be considered.
- Roles for subsequent years need to be determined with facilitator input. We suggest conducting a poll of facilitators to gain insight into their goals and desires as to what sessions they would be interested in leading and what teams they'd like to work with. There are a variety of opinions throughout the teams, and meeting these desires as much as possible will be important for maintaining high facilitator commitment to the project.

2018 Workshops

The PRODUCT team offered three workshops in 2018: workshop #6 was held at DePaul University, Chicago; workshop #7 was held in Washington, DC, and workshop #8 was held in Los Angeles. Each team

included several facilitators with 1-2 years experience, a new facilitator, and a veteran "front office" person who served as site coordinator, lead facilitator and coach. Teams were remixed as groups and somewhat by role; the new people were generally incorporated as helpers to two strands (Reading and Video) so that they got a bit of cross-training with support. As a group, the workshops received strongly positive feedback and showed evidence of improvement to specific areas noted last year.

Some strengths of the workshop design and implementation were noted across all three workshops:

- communicating that IBL is a big tent, with multiple ways to achieve IBL principles that are suited to different course and institutional settings
- showing IBL in action through video and use of active learning strategies to think about teaching with IBL approaches
- making active learning strategies explicit to participants, by demonstrating and naming them
- building community among participants intentionally, through group work, informal conversation, shared meals and social time
- linking the sessions across days, by signposting within a strand
- connecting big ideas across the strands, by showing how ideas fit together across the day and through the week
- raising participants' awareness of important issues, especially student buy-in and coverage concerns, that they will need to address in their own settings.

Participants commented positively on these facilitator behaviors:

- being welcoming, flexible, helpful, and open
- sharing expertise without arrogance, respecting everyone's contributions
- staying on schedule, adjusting if needed to protect break time and allow closure on activities.

We note particular areas where we can see improvement on issues raised in the past.

- Coherence. The thematically re-labeled schedule helped a good deal to raise facilitators' awareness of connections across the four strands and in turn participants' perceptions. It also helped to tie into big ideas such as "teaching is a system" and the "big tent" concept that IBL is an approach that must be modified to suit one's own course, students, and institutional setting. We note evidence that facilitators made more of these connections and participants responded to them.

- Closure. Coherence is also aided by more formal efforts to summarize the day's big ideas and signpost them to the rest of the week, particularly at the end of the day. Collecting "gots and needs" as an exit ticket at the end of the day is another process that helps people reflect on their experience; facilitators analyze these and make plans to address the needs the next day. Participants suggested it would also be helpful to recap and signpost these at the start of the next day.

- Modeling. Teams made an effort to point out the teaching strategies they were using and record them on big sticky notes; this seems to be reflected in comments that facilitators practiced what they preached, or used IBL to teach about IBL. This can probably be still more explicit, or

recapped at the end of the workshop, to remind people of these strategies and how they might be useful with students.

- Reading strand. The Reading strand got a good reworking prior to the 2018 workshops and it was reflected in the comments. For the first time, the Reading sessions received comments that it was the "best" aspect of the workshop for some participants. This session seems to be the most sensitive to participants' context, and it seems to be helpful to provide some strong pointers to why the reading was chosen and what people are to take away from it. This strand would benefit further from more active ways to engage participants, particularly on the first day which is a bit lecture-oriented.

Some minor things can be further improved. Small behaviors do make a difference in people's experience:

- preparing people to attend - especially sharing readings and schedule in advance; making materials accessible; reducing the number of emails.
- helping people focus and stay on task during work time. The course planning checklist is a good tool to help with this; facilitators must also resist the urge to over-plan the course content time. There seems to be a wide range of experience on whether this time is useful, and it may relate to the balance between sufficient structure to organize people's thoughts, and sufficient uncommitted time that they can make progress.
- paying attention to dynamics of individuals and small groups to make sure everyone is included and comfortable.
- easing social connections among participants, e.g. having dinner together. We recognize that facilitators are tired and need down time away from the group; they need not attend every gathering but it may be helpful to facilitate their planning by e.g. suggesting restaurants, starting sign-ups on the board, finding a volunteer to be dinner captain. One participant suggested sharing participant bios in advance.

As the evaluations reflect that the workshops are becoming quite polished, some broader issues are beginning to emerge from the data:

- Participant expectations for materials seem to be shifting, with more expectation that materials will be offered (for use or as models) in all courses. This is a change from the earlier culture that faculty would develop their own materials for students. There may be opportunities here for new efforts to develop, collect and curate.
- Diversity in the videos continues to be noticed by participants and must be carefully attended to by facilitators in their choices of sequencing and framing. Participants do comment on (perceived) gender, racial and ethnic diversity among instructors and students, but the more common concern is a perceived emphasis on proof-based classes and presentations.
- Assessment is still a topic that receives less coverage in the workshop than it probably ought to. It would be a good topic for an 'advanced' workshop or webinar series.

2017-2018 – Follow up reports (July 2020)

Follow-up surveys for the 2017 workshop cohort were administered in fall-winter 2018-19, and for the 2018 cohort in fall-winter 2019-20. For the 2017 cohort, the response rate was comparable to historic response rates, with a mean of 77%, better than the 2016 cohorts for whom we saw lower response and thus had more uncertainty about implementation. For the 2018 cohort, the response rate was a bit lower again, at 62% across all three workshops. This is a quite decent response rate but does leave greater uncertainty in our knowledge about participants' implementation of IBL approaches. These analyses are more valuable as summative measures than as formative feedback.

For 2017 participants, self-reported implementation rates averaged 71% of all participants using at least some IBL methods, and 41% teaching one or more courses they considered "full IBL." We do not know the implementation status of 23% of participants; making the conservative assumption that they did not implement, the implementation rate of 71% is a lower bound. From listserv data, we can confirm 59% of people describing use of IBL practices, which is reasonable corroboration with the rate as measured by surveys; again, some proportion of participants do not send a message on the listserv so we do not know what they are doing, and others do not give us enough clues to assess their IBL use.

For 2018 participants, self-reported implementation rates are a bit lower, mainly because response rates are lower. The total who report use of some IBL methods is 59%, and 34% report teaching one or more "full IBL" courses. On the listserv, we can confirm 45% using some IBL practices. Again recognizing that some people do not participate, both types of measurement are lower bounds.

For both groups, the patterns of change in IBL skills, knowledge and beliefs are remarkably consistent with past groups, showing that motivation and beliefs start high and are fairly well sustained after the workshop, while knowledge and skills both rise. Skills rise more gradually as people gain classroom experience with IBL. The main change in these profiles over time has been that initial self-ratings of knowledge and skills start lower: that is, people come to the workshops with less pre-existing knowledge. This is one more piece of evidence that the workshops are reaching a changing population, and it may also explain the slightly lower implementation rates we see more recently, if people who come are less persuaded already that they want to do this.

We emphasize, however, that, whatever the uncertainties in detail, our measures reflect consistently high implementation rates that the project can be proud to claim. Over half of participants do implement IBL methods in the first year after the workshop, affecting 120-150 mathematics courses and nearly 5000 students each year-- a good investment of facilitators' and leaders' time and NSF's support.

From past analyses (e.g. Hayward & Laursen, 2018) we have evidence that an active listserv offers strong practical and emotional support to participants as they implement IBL in their own classrooms. The current facilitator teams do use the listserv and prompt participants to respond, but the level of engagement is lower on both sides. We do not see the same kind of self-supporting community emerging from list-based conversations as we did under the SPIGOT project, and this may be a factor in the response rates. It may also be that this feature of the original workshop design is not replicable—e.g. it may demand different skills, orientations, or engagement of the facilitators that are less easily transferred or coached.

2019 Workshops (spring 2020)

The PRODUCT team offered three workshops in 2019: Workshop #9 was held in St. Paul, MN; workshop #10 in Portland, OR; and workshop #11 in Los Angeles, CA. Each team included some facilitators with 1-3 years experience, 1-2 new facilitators, and a veteran facilitator who served as lead facilitator and coach. Teams were remixed as groups and somewhat by role. Some new people led a strand, with planning support from their counterparts leading the same strand in the other workshops. Others co-led 1-2 strands so that they had some supported cross-training from their strand partners.

The workshops again received quite positive feedback, which emphasizes the same strengths that have been observed in past years. We take this pattern as evidence that the workshop model is robust and can be effectively led by people other than the initial developers. We also take the strong results as evidence that we can prepare facilitators through small-group planning and mentoring, despite not holding a whole group meeting as in the early years of the project. Finally, we also see some evidence of improvement to specific areas noted last year—although the needs for improvement were more modest and thus less change is observed.

Some strengths of the workshop design and implementation are seen in the workshop data:

- The workshop models inquiry in its approach to teaching with inquiry. The inquiry is focused on teaching and learning mathematics, rather than focused on doing mathematics and assuming participants will extract lessons about learning.
- The workshop is well planned: pacing is generally appropriate, time is used fruitfully, and facilitators are well prepared.
- Video sessions provide an effective backbone that scaffolds the workshop, while the other sessions support practical and conceptual needs in different and useful ways.
- Facilitators interact extensively and positively with participants, who in turn contribute meaningfully to the workshop and form new connections.

There is evidence of some improvements to the workshop this year—best described as tweaks rather than major overhauls:

- Gathering bios in advance using google slides was well received and most people participated. It made learning names easier, and it helped to generate a sense of community from the start.
- Building on last year's reworking of this strand, the literature to practice (L2P) team revised the opening session to make it more active and less lecture-based. This was well received and both participants and faciliators referenced the content later in the workshop. Overall the L2P strand is much enlivened and now serves a very useful conceptual organizing role.
- A short time at the start of day N to highlight key ideas from day N-1 is helpful in calling out big ideas and increasing coherence of the workshop as a whole.
- Efforts to incorporate equity as a workshop topic were noticed. More can be done, but we have a good start. We suggest these strategies for addressing equity in the IBL classroom:

    - Don't be shy… your role is not to be an expert on equity, but to open the discussion and make space for insights and reflections. Share this work among team members and draw on participants' expertise.
    - Bring the four pillars into the conversation early (e.g., in analyzing first-day videos) to make it clear that the equity topic is on the table.
    - Highlight equity in the L2P sessions (not just the final one) to develop common language that can be used throughout.
    - Review materials shared by the equity team for potential opportunities to integrate equity into different strands, and be ready to use those.
- Equity is a PD practice as well as a workshop topic: we want to create an equitable and inclusive space for participants.
    - Be attentive to dynamics among participants and intervene subtly or directly as needed.
    - Some people mention anxiety or other disabilities as interfering with their experience. Perhaps at the start of the workshop, or in pre-workshop communications, one facilitator can be a point person who invites people to speak with them about any needs. We will also look into ways to get this info in advance.

We note some interesting shifts in the participant group over time:

- Overall the workshops are drawing a participant group with more racial and ethnic diversity, although this is not equally the case across all 3 workshops. We credit the AIBL "ground game," deliberate and significant work to reach out to instructors at minority-serving institutions. The proportions of women continue to be high.
- Participants come to the workshop reporting *less* pre-existing belief in the effectiveness of IBL as an instructional strategy compared to past groups (see SPIGOT vs current workshop data in the graph of immediate workshop outcomes). Yet they leave with comparably high beliefs in IBL effectiveness as past groups. This is true across all three 2019 workshops and seems to represent a trend in time. It is particularly interesting since, during the same period, the workshop has responded to data on participant readiness by *reducing* emphasis on persuading people that IBL works. This may represent a shift in who is attending: e.g., AIBL's recruiting approaches may be attracting people who are less connected already to the IBL community. It may also represent a shift in the national context: e.g., as research-based instructional strategies become more normal and more accepted within mathematics, instructors may know less about IBL specifically but have enough exposure to active teaching approaches that they are willing to attend a workshop with less certainty already. We view it as a notable success that the workshops are reaching further down the adoption curve to engage less-persuaded participants yet still achieving the same good post-workshop outcomes.

Ongoing areas for attention at the workshops include:

- Participant time to think and rest are essential for a workshop as long and rich as this, and may be especially important when meeting space is cramped. We see evidence of some encroachment on breaks and loss of time for reflection, whether from sessions running into the

break, double-dipping on lunch time, or planning too much for the available time. As facilitators become more skilled and generate their own ideas, they need to resist the temptation to add more of what they have learned or to include every good activity from their growing PD toolkits. They need to make choices, stick to time, and resist the urge to comment too often; hold some topics for the email list. Don't apologize for time being tight; just make the call and move on. Preserving participants' work time is especially important, so those leading Nuts & Bolts and Course Content strands particularly need to avoid overplanning. There may be time savings in coordinating these sessions well, e.g. to use common language in discussing planning and facilitation ("alignment" seemed to be a word that was difficult for participants).

- Planning strategies to address student resistance is important. IBL implementations can founder on this rock if it's not attended to, and we also know that resistance is not inevitable: there are things that instructors can do to build student good will and buy-in. Facilitators can help by encouraging participants to take the task of preparing a student buy-in plan seriously, and by emphasizing elements of that plan beyond the first day. Student buy-in-- filling the 'well of good will'--is a good topic for follow-up conversation on the cohort-based email lists.
- The diverse experience and expertise of the facilitator team is a strength of the four-strand model. In situations where there are fewer people in the room (e.g., TWS), facilitators must be able to represent a repertoire of IBL work beyond their own classrooms. They need to be in touch with the broader IBL community and know what else is going on, who does other kinds of things or has different solutions to a specific problem. This is especially important when participants ask about overcoming barriers that they face - the answer cannot stop at, 'I don't have that problem,' but needs to continue '...but I know what colleague X or Y does.'

Issues for future work include:

- There is still a need for videos of diverse classrooms led by diverse instructors. (Note: in any selection of videos to show at a workshop, some dimensions of diversity will be missing. Some workshops have handled this issue well and proactively, e.g. raising as an explicit question how student identities may affect peers' and instructors' responses to their math presentations.)
- General response to the available IBL materials and resources is positive but some needs remain.
    - Course case studies can be used effectively in helping participants quickly assess their options. A structured activity seems essential to introduce these case studies.
    - There is a need for more IBL materials for lower-division courses, including the precalc-calc sequence, college algebra, and QR/QL courses.
    - Approaches and examples for inquiry-based statistics are also a need. Given current and past work on research-based instruction in college stats, it may be possible to meet this latter need by reviewing materials for data-rich stats courses and identifying those aligned with an IBL pedagogical approach (e.g., inclusion of student-driven explorations), rather than by developing new materials. It may be useful to identify a working group to do this or do some crowd-sourcing from the broader IBL and statistics education communities.

2019 Follow-up (Spring 2021)

Follow-up surveys for the 2019 workshop cohort (n=78) were administered in fall-winter 2020-21. Because follow-up data were no longer useful as formative evaluation this late in the project, we analyzed the combined 2019 data as a single group rather than as 3 separate workshops. The response rate is midway among historic response rates for this project, with a mean of 68%. From a statistical perspective, this response rate is more than acceptable; nonetheless, non-response is the main source of uncertainty in our knowledge about participants' implementation of IBL approaches. We note that, having delayed

For 2019 participants, self-reported implementation rates averaged 65% of all participants using at least some IBL methods, and within this group 31% reported teaching one or more courses they considered "full IBL." We do not know the implementation status of 32% of participants; making the conservative assumption that they did not implement, the implementation rate of 68% is a lower bound.

From listserv data, we can confirm that 39% of 2019 participants described use of IBL practices. For this cohort the listservs were less useful in corroborating practices than it has been for other groups. Some proportion of participants do not send a message on the listserv so we do not know what they are doing, and others do not give us enough clues to assess their IBL use. Indeed, for this cohort, individuals' listserv participation was lower than in other years (60%) though the numbers of messages on all three cohorts' lists were greater than in the previous year. The lists reflected a spring spike in email traffic as people asked questions and shared ideas for how to make the pivot to online teaching due to the onset of the COVID-19 pandemic in spring 2020. In general, however, these cohorts reflect lower participation and use of the listserv, consistent with recent trends. Given COVID-19 disruptions, we don't draw conclusions about this; we do recognize that keeping a lively listserv community is hard work.

For this group, several patterns of change in IBL skills, knowledge and beliefs are broadly consistent with past groups. Motivation starts high and is fairly well sustained after the workshop, while knowledge and skills both rise. Skills rise more gradually as people gain classroom experience with IBL. As noted in the prior analysis, one interesting difference of the 2019 group from past groups is their lower initial belief in the effectiveness of IBL. Compared to past workshop groups, the workshop made a bigger difference in their belief about IBL effectiveness; like other groups, this level of belief was sustained post-workshop. We continue to think that this reflects a difference in the audience the workshops are reaching, as discussed previously.

Another interesting difference for this group is the average drop in IBL knowledge that participants report at the follow-up mark, which is not typical. They also report more modest gains in skills in the post-workshop year than is typical. Perhaps administering this survey in late fall 2020, after several months of online or hybrid teaching, caught instructors at a time they felt discouraged with their ability to pull off IBL in online or unusual hybrid teaching structures or had not used IBL as much as they had intended. Nonetheless, it is encouraging that they do not report loss of motivation to use IBL or belief in its effectiveness.

In sum, our measures reflect consistently high implementation rates that the project can be proud to claim. Nearly two thirds of participants implement IBL methods in the first year after the workshop, affecting an estimated 140 mathematics courses and 3600 students each year.

2020 Workshops (Spring 2021)

The PRODUCT team offered three workshops in summer 2020, all held online due to the worldwide COVID-19 pandemic. Each team included some facilitators with 2 or more years experience, and we made sure to include the facilitators who were new in 2019. Teams were remixed as groups and somewhat by role. Strand assignments were looser and more malleable in the online format; many people tried or team-taught new strands. In general planning was more focused within each workshop team and there was less cross-workshop, strand-based planning, a natural response to the extra stresses of life and work during the pandemic. Two of the workshops used intensive formats with activities on four contiguous days, and one used an extended format with sessions spread across 3 weeks.

The workshops received quite positive feedback noting many of the same strengths historically observed for these workshops. The fact that this was the result during a time that was stressful for everyone is testimony to the hard work and creative thinking of the facilitator teams who prepared and hosted the workshop. Strengths of the workshop that recurred in participant feedback include:

- Thorough advance planning, thoughtful logistics, and good use of technology in activities
- The use of video as a backbone of the workshop for providing common images of IBL and opportunities for discussion
- Intentional community-building and design of activities to foster interactions; the opportunity to interact with others who share an interest in this kind of teaching
- Useful content and extensive resources provided by the workshop leaders
- Modeling of IBL practices in the workshop itself, as well as modeling of how interactive teaching can be accomplished in fully online environments
- Praise for the leaders' enthusiasm and expertise.

Participants and facilitators noted both affordances and limitations of the online format. Affordances emphasized accessibility by enabling people to participate who were managing other responsibilities at home, such as childcare, and by eliminating travel costs. It is possible that this explains the high proportion of women who took part (58%) and the growth in two-year-college participants (27%). Some unexpected affordances surfaced from using technology, such as the ability to enrich discussion with conversations in the Zoom chat window. "Now you are allowed to pass public notes during class, which adds another level of interaction and community-building," noted one facilitator. It appears that participants were more aware of the resources shared with them, perhaps because they were more integrated into their workshop experience (via a website hub or LMS) or more organized there.

Despite use of the chat, a limitation of the online format was the difficulty of getting to know everyone because it was harder to interact informally with participants in online spaces. This may be related to facilitators' observations that participants seemed to get less done on their course planning. Based at home with other responsibilities, they may have spent less time doing this work, and it was also harder for facilitators to circulate, assess, and prod participants individually. Facilitators also noticed that cutbacks they made to the content covered in the Nuts and Bolts and Course Content strands—needed to enable the more streamlined schedule needed to accommodate people across time zones—meant that participants had more unanswered questions about course design, lesson planning, and facilitation.

Some comments suggest improvements that can be made in future online workshops. Perhaps the most general need is to pay careful attention to the schedule to allow rest, reflection, and processing time. In

this respect, the workshop schedule using 75-minute sessions drew fewer comments participant about "feeling rushed" than did those with 45-minute sessions. Indeed facilitators were aware of extra overhead in getting people into and out of breakout rooms while still leaving time for a debrief. We have separately gathered much of facilitators' practical advice and insights about online workshops in a handbook (Daly et al., 2021).

We applied our standard analysis of open-ended comments to identify participant concerns that were raised, dispelled, or lingering after the workshop. We made one pandemic-related modification, splitting the survey question eliciting these to distinguish concerns about IBL in face-to-face (F2F) settings from those about IBL in online settings, since we knew that workshop participants had anxieties about online teaching and that facilitators were concerned not to be expected to be experts about teaching online with IBL. Overall these concerns closely mirror those typically reported after in-person workshops, and we do not see any red flags in the concerns that are raised or lingering.

This year's feedback also showed an increase in the frequency of positive comments about how it addressed classroom equity, which has been a growing feature of the workshops. In 2020 this topic was explicitly addressed by including equity-focused plenary sessions and facilitators' intentional weaving of equity topics within other strands and activities. For the first time, equity appeared as a raised concern for participants, which suggests that they were led to new thoughts about their classroom practice by what facilitators incorporated. The prevalence of this topic in the feedback is evidence that facilitators continued to be more explicit about incorporating equity considerations for teaching, more deliberate in finding and using opportunities to raise this topic, and more attentive to considering equity in their own practice as professional developers. This is an improvement that is responsive to past evaluation feedback. (Given differences in the delivery format, we do not otherwise compare implementation to prior years.)

Overall, the feedback points to a very successful experiment in translating the workshops to an online format and highlight the potential benefits of an online workshop format going forward.

Data Sources

For each workshop, participants are asked to pre-register online and complete a brief survey; a similar survey is administered in person on the final day of the workshop. In the fall one full academic year after the workshop (about 17 calendar months), participants are invited to complete a third, and final, online survey. By asking some of the same questions at each of these three time points, we can assess how instructors' practices and beliefs change over time.

All surveys include quantitative items and open-ended questions. Likert-scale items reflect participants' knowledge, skills, and beliefs about inquiry teaching, as well as their motivation to use inquiry methods and their perceptions of the overall quality of the workshop. Participants describe their use of particular teaching strategies both before the workshop and at the follow-up survey, using both closed- and open-ended descriptors that we have developed (Hayward and Laursen, 2014). Open-ended questions address the costs and benefits of using inquiry strategies, participants' impressions and learning from the workshop, and how they may use that learning in their own educational activities. On follow-up surveys, multiple-choice and open-ended questions assess participants' use of IBL methods and engagement with other IBL-related events and resources subsequent to the workshop.

Participants report personal and professional demographic information such as career stage, institution type, gender, race and ethnicity, so that we can analyze for differences between groups. Race and ethnicity are only collected for US citizens, nationals, and permanent residents since concepts of race and ethnicity are different outside of the US. For 2016 cohorts, respondents provided some unique identifiers on each survey that were used to match responses across the three time points while maintaining anonymity. Starting in 2017, surveys are collected and matched by name, and then de-identified in the dataset.

For 2020 workshop cohorts and 2019 follow-up surveys, we made some modifications to survey items to recognize pandemic-related shifts in practice. Namely, in all surveys probing teaching practice, we added a "COVID block" of questions, developed in conjunction with Tim Weston, asking participants to describe the teaching practices they used after the pivot to online instruction and compare them with those used before the pivot. Some extra questions probed the support and challenges that instructors had encountered and the challenges that they were aware students faced.

For the 2020 workshops, which were offered fully online, we modified questions in order to distinguish instructors' needs and expectations around teaching IBL online vs. face to face (F2F). One goal was to support the facilitators in setting appropriate expectations (especially that the workshop would address general principles but would not be an online IBL how-to course) and to tease out concerns about teaching online from those about teaching with IBL in general. Likewise, we asked instructors to separately rate their IBL knowledge, skills, etc., for using IBL in online and F2F settings.

Some survey items were adapted from prior evaluations of faculty development by our group (Thiry, 2007) and other items were developed based on discussion with workshop leaders about their goals and expectations for workshop attendees; most had been previously applied in prior workshop evaluations (Hayward & Laursen, 2014; Hayward & Laursen, 2016). The study design and instruments were approved by the CU Boulder Human Research Committee. For some workshops, one evaluator attends as a participant observer, which helps us to understand group dynamics and interpret survey comments.

Methods

Responses to numerical items are entered into the statistical analysis program SPSS (IBM Corp., 2012), where descriptive statistics are computed. Means and standard deviations are computed for some of the ratings items, and frequencies are computed for all of the items. If participants leave some items blank, these responses are omitted in calculating means and standard deviations for survey items. Pre-workshop, post-workshop, and follow-up responses are matched, which allows us to test for changes in each individual's responses (paired sample comparisons), not just changes in the overall group means. Open-ended responses are entered into MS Excel (Microsoft, 2011) and analyzed for trends based on the frequency of occurrence of common qualitative themes.

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