Appendix A7
Study Methods for Student and Instructor Interviews

A7.1 Introduction

We conducted semi-structured, in-depth interviews with samples of faculty members, graduate students, and undergraduates at all four institutions. Unlike surveys, academic records analysis, or other quantitative research methods, interviews allow participants to offer detailed, spontaneous accounts of their experiences, views and attitudes, as well as explanations and evidence supporting their observations. As well, the conversational style of interviews allows the researcher to probe participants' comments more deeply for clarification or to better understand their basis. Participants can raise new issues, or emphasize points important to them. Thus, the instructor and student interviews complement the types of data collected in the other sub-studies, offering data that can help to explain, confirm, or validate findings from the other sub-studies.

A7.2 Instructor interviews

The instructor interview study was designed to gather instructors' perspectives on student outcomes, classroom learning and teaching processes, and their own experiences. We sought to address the following questions:

- What student gains (or failures to make gains) do instructors observe as a result of IBL instruction?
- How do instructors describe their classroom practices (including planning, course materials, assignments, assessments, teaching methods, etc.), with what rationale(s) behind them? What teaching issues do IBL instructors face, especially issues that are different in nature or scale from those in non-IBL classrooms, and how do they resolve them? What advice do they offer to other IBL instructors?
- What are the costs and benefits to instructors of teaching with IBL methods?
- What are the personal, professional, departmental and institutional conditions under which IBL courses are effective and sustainable, or not? What professional resources are needed to begin using IBL methods, and how (if at all) do instructors obtain them?

Graduate students played an important role in many of the IBL courses we studied, sometimes as teaching assistants and others as lead instructors. Here we use the generic term "instructor" to include all those in instructional roles. We specify "faculty" (including anyone in the lead instructor role, regardless of their appointment type) or "TA" when it is important to distinguish specific classroom roles.

A7.2.1 Instructor interview sample

All four campuses participated in the instructor interview study. Based on information from the campuses, we prepared a list of all active or previous instructors of IBL courses in the past three

years, and all graduate student TAs who had participated in an IBL course in the same period. At some campuses, this included graduate students or postdocs who had left campus but who were teaching elsewhere and could be located. This yielded a list of 10 to 19 individuals per campus. We excluded two individuals for logistical reasons (e.g., on sabbatical overseas) and invited all the rest, by e-mail, to interview with us in person during a scheduled visit to their campus. For those who had left campus, we invited them to a telephone interview. Telephone interviews were also conducted with a few instructors who were unavailable during our campus visit.

This approach yielded five to 15 interviews from each campus, for an overall response rate of 77% (varying from 50% to 88% by campus). Altogether, 43 interviews were conducted with 44 individuals (one pair of TAs for the same course was interviewed as a focus group). Three digital recordings exhibited severe interference. After digital editing to reduce noise using Audacity software, two were able to be transcribed, but one was unsalvageable and no transcript could be prepared. Thus the final sample for analysis included 42 interviews with 43 individuals.

Of the 43 instructors interviewed, 31 were men and 12 women. Nearly all were white. Approximately 15% were born outside the US. Most of the instructors taught courses for math or STEM majors (labeled as "math-track" courses elsewhere); seven of the 42 primarily taught IBL courses for pre-service teachers.

Those in faculty positions included 23 holding tenurable (pre- or post-tenure) and non-tenure-track appointments, including both long-term lectureships and short-term postdoctoral positions. About half of these were new to IBL methods at the time we spoke, and the remainder had one year to decades of prior IBL experience. The faculty sub-sample was predominantly male.

Twenty interviewees were graduate students at the time of their IBL involvement. They ranged from second- to seventh-year students, and a few had graduated and moved on to postdoctoral or tenure-track teaching positions. Their IBL teaching experience ranged from one term to several years. The graduate student sub-sample was nearly gender-balanced.

A7.2.2 Instructor interview protocol

The interview protocol addressed participants':

- Career stage, teaching experience, and (for graduate students and postdocs) future career plans
- Role in the IBL course, and how they became involved
- Teaching philosophy, style, and strategies
- Observations of student gains, including gains in knowledge, understanding, skills, approach to problem-solving or learning, and later impacts (such as later course choices or career selection)
- Observations of any differences in who achieves these gains—by race/ethnicity and gender, and by characteristics such as work ethic, temperament, intellect

- Costs and benefits to the instructor him/herself of teaching with IBL methods
- Influences of their IBL teaching experiences on their teaching philosophy, classroom style, or beliefs
- Experiences of learning to teach with IBL methods, including difficulties, professional development, and collegial support (or lack of it), and advice they would give to students preparing to take an IBL class, and for colleagues preparing to teach one.

With early-career interviewees, we asked about the impact of IBL teaching on their career interests and prospects. With senior faculty and department chairs, we asked about their departmental colleagues' perspective on IBL and their views of the IBL program's sustainability in their department.

A7.3 Undergraduate interviews

Interviews with undergraduates investigated students' perspectives on their experiences in IBL mathematics courses, outcomes of IBL instruction, and classroom learning and teaching processes. Thus, we sought to address the following questions:

- What do students gains (or not) as a result of IBL instruction?
- How do students describe their instructor's classroom practices (including course materials, assignments, assessments, teaching methods, etc.)? How do these differ from more traditionally-taught mathematics courses? How does this affect their learning? What advice do they offer to other students taking an IBL course?
- What difficulties do students encounter when learning with IBL methods? What resources are needed or available to help them overcome these difficulties?
- Do some students benefit more than others from IBL methods?

A7.3.1 Undergraduate interview samples

At three campuses, undergraduate interview samples were constructed from comprehensive lists provided by each department of all students currently enrolled in an IBL mathematics courses. Student samples were selected so as to balance the representation of demographic characteristics such as gender, race/ethnicity, and major. Interviews with students were solicited and scheduled by e-mail. This approach yielded about 20 interviews at each campus. At the fourth campus, students currently taking an IBL course were contacted by an academic advisor and invited to contact us to volunteer for an interview. This approach yielded a rather smaller interview sample from this campus, which is not necessarily representive.

The final student interview sample was composed of 68 students who had participated in an IBL mathematics course in the current or prior semester at one of the four IBL Centers during the 2008-10 academic years. Nineteen students were interviewed individually; the remaining 49 students participated in one of 22 focus group interviews, with 2-4 students each. Students who

interviewed together in a focus group had taken the same IBL mathematics course and so were able to offer comments about the same class.

Demographic data were reported by students themselves on a standardized data sheet, except for course type, which was categorized by the research team. Table A7.1 provides an overview.

Table A7.1: Distribution of undergraduate interviewees by institution, gender, race/ethnicity, discipline, type of mathematics course, and interest in teaching

Demographic group	Number	Percentage
By gender	**68**	**100%**
Female	38	56%
Male	29	43%
Did not respond	1	1%
By race and ethnicity	**68**	**100%**
White, not of Hispanic origin	48	71%
White, of Hispanic origin	6	9%
Black, not of Hispanic origin	1	1%
Asian	9	13%
Multiple races	2	3%
Did not respond	2	3%
By major	**68**	**100%**
Mathematics	35	51%
Science	14	21%
Engineering	2	3%
Non-science	14	21%
Did not respond	3	4%
By type of IBL course	**68**	**100%**
Advanced	35	51%
First-year	19	28%
Pre-service teacher	14	21%
By teaching interest	**68**	**100%**
No interest	41	60%
Secondary	13	19%
Elementary	11	16%
May go into teaching	2	3%
Did not respond	1	1%

Over half of all students interviewed were female, and nearly three-quarters were white. Among non-white students, most were of Asian or Hispanic heritage; only a few students were African-

American. Overall, the race and ethnicity distribution of the student interview sample was typical of the departments participating in the study.

A range of majors was represented in the student sample. In all, just over half of undergraduate participants were mathematics majors, and about one fifth were in a science field. Another fifth of the student sample was in a non-science major. A few students were pursuing engineering.

Just over half of the student sample was enrolled in an advanced mathematics class for upper-class students, while 28% were in a course for first-year students, and 21% were taking an IBL course designated for pre-service K-12 teachers. Separately from their course enrollment, students separately reported their interest in teaching. In general, students pursuing elementary teaching were those taking designated pre-service courses, but, as the data show, other students pursuing high school teaching were enrolled in advanced mathematics courses.

In all, a total of 41 interviews were conducted with 68 students. From the demographic data, we may infer a strong interest in mathematics among many students in the sample. As well, a good number were thinking of teaching mathematics as a career.

A7.3.2 Undergraduate interview protocol

Interviews with undergraduate students probed their experiences in IBL mathematics courses, as well as their attitudes and opinions about learning by the IBL method. To better understand student outcomes arising from IBL methods, particular attention was given to exploring students' reports of how their gains had been made. Students were asked:

- About their background and academic goals (major, year in school, plans following college (i.e., career, graduate school), what math courses they had/were taking and why
- To describe how the current/most recent IBL course was taught; how it compared to non-IBL mathematics courses they had taken
- How the IBL method affected their learning, and whether they felt they learned well this way (why or why not)
- Whether they felt they were covering the material they needed for future mathematics or other coursework
- The best and worst things about how the course was taught
- What did they gain, or learn, from the class—or not—and what contributed to or detracted from their learning
- Whether they would take more mathematics courses and if they would choose an IBL over a non-IBL course
- Whether the IBL course had changed ideas about career or graduate school plans
- To offer advice to other students, their instructors, the department or institution.

All interview protocols were submitted for review and approved by the University of Colorado's Institutional Review Board to ensure that this study met high ethical, professional and legal standards for research involving human subjects. Interviewees read and signed an informed consent agreement that described the study and their rights as research participants to anonymity, confidentiality and other protections of the information they provided. They could decline to answer any questions, stop the interview if desired, or decline to be recorded.

A7.4 Methods of qualitative analysis

For both the instructor and undergraduate interview data, we followed a method of formal content analysis. Our methods of data collection and analysis are ethnographic, rooted in theoretical work and methodological traditions from sociology, anthropology, and social psychology (Berger & Luckman, 1967; Blumer, 1969; Garfinkel, 1967; Mead, 1934; Schutz & Luckman, 1974). Qualitative research, such as these interview studies, is particularly useful where existing knowledge is limited, because these methods can uncover and explore issues that shape informants' thinking and actions. Qualitative computer software allows for the multiple, overlapping, and nested coding of a large volume of text data to a high degree of complexity, thus enabling ethnographers to disentangle patterns in large data sets and to report findings using descriptive statistics. Although conditions for statistical significance are rarely met, the results from analysis of text data gathered by careful sampling and consistent coding can be powerful.

Digitally recorded interviews and focus groups are transcribed verbatim into a word-processing program and submitted to *NVivo 8.0*, a computer software program used for qualitative data analysis (QSR International, 2009). The analyst reads through all of the documents—the text data—searching for information relevant to the research questions. Text segments referencing distinct ideas are tagged by code names. Codes are not preconceived, but empirical: each new code marks a discrete idea not previously raised. All of the code names that are developed are collected in a codebook. When the analyst reads a text passage that relates an idea previously encountered, the same code name is reused to mark the relevant passage. Thus codes and their associated text passages are linked, amassing a data set of code names and their frequency of use across the data set. Once all of the text data is coded in this manner, codes similar in nature are grouped together to define analytical themes. For instance, the themes we identified for student learning gains from participating in an IBL mathematics course sorted into five categories: "cognitive or intellectual gains," "understanding the nature of mathematics," "changes in learning," "affective gains," and "communication gains."

The clustered themes or categories describe the nature and range of issues in participants' collective report, and the frequencies with which the themes appear characterize the relative weighting of these issues. That is, frequencies show us what participants have commented on "the most," "some," and "the least." The number of observations is generally much larger than the number of speakers, and thus is a measure of the depth of commentary on broad topics. The number of speakers raising an issue, however, is often a better measure of the distribution of

views on a topic. We use both types of counts in reporting results of the qualitative analyses of the student and instructor interview data.

In order to discover whether or not there were meaningful variations in what was reported by different student groups, we also analyzed the student interview data by gender and by course type (first-year, advanced, or for pre-service teachers). These analyses allowed us to explore important questions, such as whether or not women offered more observations than did men concerning their learning gains, or whether students who had taken mathematics courses designed for pre-service teachers noted unique or particular learning gains compared with students who had taken an advanced or first-year mathematics course. For instructors, subgroup analyses compare faculty with graduate students, and experienced with new IBL instructors.

When the subgroups are different in size, it is easiest to compare code frequencies on a per-capita basis, considering the average number of observations per person interviewed, rather than simply the total number of observations. This takes into account the fact that a larger number of interviewees will generally offer a larger number of observations on any topic. However, because interviews are conducted in a conversational manner that allows for topics to arise in a natural order or new topics to be introduced spontaneously, these frequencies are not appropriate for statistical analysis.

A7.4.1 Content of the instructor interview codebook

The instructor interviews codebook included a total of 2414 coded passages, coded into five main themes with 8-14 sub-themes under each. About 40% of instructor comments addressed processes of teaching and another 17% addressed processes of learning. Instructors' observations of student gains (16%), impacts on instructors' own personal and professional lives (16%), and comments on their departmental, disciplinary, and institutional context (10%) comprised the remainder of the codebook.

A7.4.2 Content of the undergraduate interview codebook

The undergraduate interviews codebook included a total of 3390 coded passages, coded into 13 main themes: four main themes included 1-8 sub-themes, which were sometimes further subdivided. Thirty-seven percent of students' observations discussed how gains from an IBL mathematics course had been made; that is, processes that supported their learning. A further 24% of student observations noted specific learning gains from IBL, while smaller bodies addressed gains not made (3%) or "mixed" gains made in partial or qualified degree (1%).

Nearly 10% of student comments were comparisons between IBL and non-IBL classrooms. Another 10% of students' comments were in the form of advice, either to other students or to instructors teaching future IBL mathematics classes. Smaller numbers of observations were offered concerning: the choice to take (or not) another IBL mathematics class (5%), career and graduate school plans (3%), the longer-term impacts of taking an IBL mathematics class (3%), and whether or not women or students of color benefitted more from IBL methods (2%). The remaining comments were miscellaneous in nature.

A7.5 Limitations of the interview studies

While the interview samples are generally large for qualitative work, and appear to broadly represent the student and instructor populations at the IBL Centers, there are some limitations to the interview findings. This particular sub-study did not include a comparison group of students who had taken a non-IBL mathematics class. Data from a comparison group could help to highlight areas in which IBL students' gains were either particularly strong, or unremarkable.

As in any interview study, participation was voluntary, and our samples of both students and instructors may over-represent either those who were especially enthusiastic about the method, or those who had an axe to grind. The sample size was small at one institution where we secured only a handful of student interviews. Because each campus had a distinct style of IBL, descriptions of the classroom activities and characteristics experienced by these students may be underrepresented in the codebook. Though every attempt was made to include students of color in the interview sample, the low fraction of non-white students enrolled in these courses precluded any data analyses that might provide insight into the benefits (or lack of them) of IBL methods for students from groups traditionally underrepresented in mathematics. Likewise, we do not have large enough sub-samples for any single course to analyze patterns for specific courses or campuses.

The instructor sample is robust in size and a good match to the apparent demographics of the instructor population at these campuses. We note that the instructor sample is composed of people who chose or were invited to teach IBL courses. While our observations and interviews do not indicate that they are unusually talented as teachers, they may well be more interested in student-centered teaching methods (and in students themselves) than the average mathematics instructor. We make no claims about the applicability of our findings to all mathematics instructors, but (as discussed in Chapter 8) we do believe that their observations indicate experiences and issues that instructors in other settings are likely to encounter .

A7.6 References Cited

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Exhibit E7.1: Interview Questions for IBL Math instructors individual or focus groups (pairs)

Review consent form, confidentiality and anonymity. Clarify audio recording procedures. **Tell them to keep other names confidential, per HRC:**

> Please do not disclose the name of other students, faculty or staff members when being interviewed. When participating in a focus group please keep all information that is shared in the session confidential.

Turn on mic!

A) Background and teaching experience

Tell me a bit about yourself – what you do here how you are connected to the IBL project here.

> Teaching experience (years, where and what)
> Career status
> For grads/postdocs: future career interests, timing (where now in education/professional process, when will they be job hunting)

B) Teaching style and strategies

Tell me about your course: who takes it, what are your goals for these students
What is your overall teaching approach or philosophy?
What particular strategies are you using to achieve this? Why those (and not others)?
How is this working? (What are you happy or not happy with, in how the course is going?)
Will you teach this way again? The same way or differently? (What will you change?)

C) Role in IBL project (if instructor in IBL course)

How did you get involved in the IBL project at your campus? Did someone ask you or did you volunteer? (why do you think they picked you?)
How do you define IBL, for yourself?

> What goes on in this course that you think is different from the way most math courses are taught?
> How does IBL fit in with your own beliefs about teaching and learning?

D) Observations about student gains

What do you think students get out of your courses? (Open-ended, then probe for specific categories:

> understanding of mathematics content
> understanding of the nature of mathematics, how mathematicians work
> communication skills – writing and speaking about math
> critical thinking skills or habits of mind
> attitude changes: confidence, enjoyment, interest in mathematics
> changes in your problem-solving style, ways of learning math (independence, persistence, reflection)
> Any other gains we have not mentioned yet?

Do you see any impacts on their course-taking afterwards? Career or grad school plans?

> Probe particular benefits for the grad-school bound
> For life in general

What do they not get? (OR what do they miss out on, that they get in other places?)
For what type of student does your teaching approach work best? Why do you think so?
Do you notice any patterns in which students respond well or not – e.g. with respect to gender, ethnicity, background?
For non-IBL instructors: Are you familiar with the IBL project on your campus? (to set up next questions for them – but ask All
What kind of students learn best from IBL?
What makes IBL difficult for students?
What kinds of students find this particularly difficult or daunting?
Do you think every student have an IBL experience as part of a college math degree? Why or why not?

E) Personal and professional gains/costs

What do you, as a teacher, gain from teaching this way?
What are the costs to you of teaching this way?
What do you like/not like about this approach?
Have your beliefs about teaching and learning in any way? (why or why not?)
(Ask about linkage to IBL course for IBL instructors)

F) Additional questions for **grad students** helping or TAing IBL courses

What do you find yourself doing – what is your role in supporting students in the course?
What do you think works well about that?
What is difficult about that?
What do you get, personally, out of doing this work?
How do you think your work with this course has influenced your own ideas about teaching and learning, so far?
Do you think you would choose to teach this way if you were in charge of a course yourself?
(Given career goals) How do you think working witih this course will prepare you for that career?
Probe career expectations re teaching, type of teaching, in particular.
Ask if we can keep in touch to follow up on their career progress; get permanent contact info if possible.

G) Additional questions for instructors also in a leadership role in the project

Tell me about how this department, as a group, and you as an individual, got involved in IBL.
How have you recruited or persuaded others to participate?
Has that been hard or easy?
What kind of people seem most interested in teaching this way?
What status issues do you observe around participating in IBL?
What are the barriers or difficulties that people raise who don't want to teach this way, or who are reluctant? (why do some people not want to do it?)
What in your view have been the successes ?
Why, or what are your criteria?
What have been the challenges?
Why? What makes it hard?

Any outright failures?

Tell me a bit about your interaction (or the project's) with the other campuses.

How often do you meet, how well do you know the other people or projects?

What do you get out of this interaction?

What is your perception of how IBL is done at this campus as compared with how it is done on other campuses?

H) Advice

Any advice you'd want to give the faculty or department about this course or this approach?

Any advice you'd want to give another instructor (TA) for this course?

Anything we should have asked that we didn't? Anything you want to add or emphasize?

Thanks, follow-up, goodbye.

Exhibit E7.2. Interview Questions for IBL Math students - individual or focus groups

Revised January 28, 2009

Review consent form, confidentiality and anonymity. Clarify audio recording procedures. **Tell them to keep other names confidential, per HRC:**

> Please do not disclose the name of other students, faculty or staff members when being interviewed. We understand that in some cases the name of an instructor may be understood if you are taking a particular class that is being discussed. When participating in a focus group please keep all information that is shared in the session confidential.

Turn on mic!

Background and academic goals

Tell me about yourself —what's your major, what year are you?

> What do you plan to do after college? (career, grad school plans)
> What math course are you taking (did you take recently) and why are you taking this course?

Learning experiences

Tell me about how this course is taught, compared to other math courses you've taken here.

> Did you know it would be like that, when you signed up?
> How does it compare to what you expected?

How do you think this way of teaching math affects your learning?

> Do you feel you learn well this way? Why or why not?
> Do you enjoy it ? Why or why not?
> Why do you think the instructor chooses to teach it this way?

How do you feel right now about how it's going ? (Ask in retrospective form, for past students—How did it go? Did you learn the material, get a good grade?)

> Do you think you'll learn the material you need to learn to go on in math or in other courses in your major?
> Do you think you'll get a good grade?
> Do those things worry you ?

What's the best thing about how this course is taught?

What's the worst thing about how this course is taught?

Learning gains

Overall, what do you think you are getting (got) from this course? (Open-ended first, then prompt for "some of the things faculty think students gain from this kind of course") :

> understanding of mathematics content
> understanding of the nature of mathematics, how mathematicians work
> communication skills – writing and speaking about math
> critical thinking skills or habits of mind
> attitude changes: confidence, enjoyment, interest in mathematics
> changes in your problem-solving style, ways of learning math (independence, persistence, reflection)

Any other gains we have not mentioned yet?
Are you likely to take more math courses ? (would you have done so anyway?)
Any changes in which courses you think you'll take next?
Any changes in your ideas about your career or grad school plans, after taking this course?

Advice
Based on your experience, what kind of student do you think is most likely to succeed with this type of course?
What kind of student do you think will find it difficult or not to their liking?
What would you tell a friend who was thinking of taking this course?
Any advice that you'd like to give the faculty and department about this course or this way of teaching?
Anything else that we should have asked you about?
Anything else you want to add or emphasize?
Thanks, followup, goodbye.