Increasing Inclusion in Large Enrollment, Uniform Math Courses: Instructor Training and Course Assessment

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Dimension of Change 1: Training for New Instructors and Ongoing Teaching Support

To support instructors who are new to teaching in our introductory math courses, we run a training program during the week before classes start in the fall term.[3] The overarching goal of this program is to motivate instructors to teach in an interactive, inquiry-focused manner, and to provide them with the experience and tools they need to do this effectively. The program format and topics have evolved over the years, and currently focus on experiential practice. The participants practice and receive feedback on lecturing, experience a model class as students to see how it can promote learning, and practice running this type of class themselves. There are also sessions on the logistical and administrative aspects of teaching. The program has also a strong emphasis on getting buy-in from the participants and on how they can get student buy-in when they go into their classes.

We have added an inclusive teaching workshop to the first day of this program and made complementary changes to the content of the programming in the remainder of the week. The two-hour workshop, run by our campus Center for Research on Learning and Teaching, follows a theatrical skit and discussion that bring out issues of inclusive teaching. The workshop starts by introducing instructors to the idea of teaching inclusively and why it matters, emphasizing that as inclusive teachers they must be deliberate and aware of the impact of students' identities and systemic inequities. It then provides concrete strategies that they can use to increase transparency about expectations and evaluation criteria, cultivate a sense of academic belonging in their classrooms, and increase the structure of classroom interactions to promote an inclusive classroom community. Changes in the programming in the remainder of the week include use of these strategies in sessions on group work, and a focus on norms and expectations for classrooms and student teams.

Recognizing that developing and refining one's teaching philosophy takes time, we also provide ongoing support to our instructors. In their first semester teaching, all new instructors receive one or two class visits to provide constructive feedback on their teaching and on teaching inclusively. Additional support is provided by weekly course meetings to discuss course material and the logistics of teaching it, and in our course preceding calculus[4] we have added to these two follow-up workshop sessions on inclusive teaching for instructors. We also solicit student feedback mid-semester for the instructors to use to improve their teaching.

There are several key lessons from this dimension of change. First, graduate students found activity-based sessions in the new instructor training program (especially those pertaining to group work and inquiry-based learning), and informal discussions with other instructors and with course coordinators, to be particularly valuable. Second, these informal supports continue to be rated as helpful for instructors with more experience. And third, additional mentorship and feedback on teaching, as well as more opportunities to build a peer support community, were the most frequent suggestions for further support. Finally, we note also an ongoing challenge for our program: while many of our instructors are fully invested in the work of teaching (and teaching inclusively), this competes with the academic norm of the preeminence of research. As such, a challenge we face is to shift the mindsets of (some of) our new instructors so that being an effective and inclusive instructor is considered a fundamental part of being a successful mathematician.

This work to help new instructors teach inclusively exists in the context of a wider effort in our department to create a community of instructors who teach inclusively, and to build a consensus in the Department that this is necessary. We have an ongoing Learning Community on Inclusive Teaching (LCIT) that meets on a monthly basis to provide an informal space in which instructors are able to discuss selected readings on inclusive teaching, raise questions they

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[3] *The instructional team in charge of this program includes coordinators and graduate student co-coordinators of the introductory courses, undergraduate directors, and some other associated faculty.*

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[4] *Because this is the course on which we focused initially, these workshop sessions were done for those instructors. We expect that this will expand as we focus also on Calculus I and II.*

have about teaching, and recommend things they have done in their classrooms that have worked well. In many respects, this provides an existent space in which some of the informal support that instructors have as they start to teach can continue, with a specific focus on inclusive teaching. The LCIT meets over lunch, and for its first two years of existence has been supported by small university grants that have allowed us to provide lunch for the participants.[5] While participation in the learning community is voluntary, it accomplishes—for its participants—the goals of providing a venue for continued exploration and support of inclusive teaching in the department. It has engaged a significant number of instructors who teach our introductory courses. Reaching all instructors in the Department and building a consensus that this work is essential presents a much bigger problem that requires systemic change at a larger scale than the courses in which we are currently working. This is work we must do but is beyond the scope of the project we describe here.

Dimension of Change 2: Course Assessment

Core to the philosophy and pedagogy of our introductory courses is an emphasis on conceptual understanding, learning as a growth process, and a small class, active-learning instructional model[6] that has been shown to be supportive of all students in mathematics. To better align the primary assessment in our course preceding calculus with this set of core principles, we have developed and pilot-tested a new assessment structure for the course that includes a significant mastery learning component. This replaces a model in which 95% of students' course averages was generated by three timed (and necessarily high-stakes) exams and a scaled grade distribution,[7] which has been shown to put women and underrepresented minorities in STEM at a disadvantage (Madeaus & Clarke, 2001; Piontek, 2008). By contrast, a repeatable, low-stakes assessment that allows students to build understanding and ownership of the course material addresses many of the factors that have been shown to drive these students away from STEM fields (Seymour & Hewitt, 1997).

In the new assessment model, 50% of the points determining students' grades are earned on repeatable mastery assessments, and a further 10% from work done in class and class assignments. The remaining 40% is derived from two timed but much lower stakes exams that are shorter and significantly less formidable than the previous three. This model has two key features. First, it constitutes a comprehensive revision to the assessment in the course, in which the components are realigned for consistency with the course, other assessments, and course goals. And second, it aligns the grading structure of the course with the core goal that students learn in a growth mindset (Dweck, 2006) manner, which aligns with our core course goals.

The development of the mastery assessments followed a model characteristic of such work: we determined first a comprehensive list of learning objectives for the course, and then created a set of repeatable assessment problems with randomized parameters that allow us to determine whether students have mastered each. These are grouped into eight assessments, each having five questions, which we administer using our on-line homework and testing system (WeBWorK, n.d.). Because our goal is for students to master the learning objectives, we require that students answer four or five of the five questions correctly to receive partial or full credit for the assessment. In total, students can earn 35% of the points in the course by completing these assessments. At the end of the semester, we have a final mastery assessment which includes topics from all preceding assessments and is ten questions long. These scores contribute an additional 15% of the points towards students' course grades. For all mastery assessments, students can practice as often as they like online, and receive credit by obtaining a high enough score when taking it in a proctored lab.[8] The lab is open 40 hours a week and students have approximately two weeks to complete each mastery assessment. We have also allowed students to choose two assessments to reopen at the end of the semester.

To complement the use of the mastery assessments, we made two additional changes to the course. First is an increase in the assessment weight of the work that students do in and for their class section. In the past, students' work on the web homework for the course was the last 5% of the credit in their course grade. Now, 10% is determined by their work on the web homework, quizzes in their section, and team homework done with other students. The team homework requires the solution of significant, conceptual problems, which students submit in carefully written solution papers describing their work and the mathematics they used. Both the problem work and the solution paper are produced collaboratively by the team. The final change to the course assessment is, of course, in the timed exams. We changed from two midterms and a final to two exams, one a

[5] *The department also has an Inquiry Based Learning Center which also holds informal lunches, the focus of which clearly complements the inclusive teaching lunches.*

[6] *As a general rule of thumb, we expect instructors to lecture in blocks of 20 minutes or less, and that at least half of the time in class will be spent on exploratory activities that students work on in groups.*

[7] *We note that while scaled based on a historical understanding of the meaning of students' performance, grades were not "curved" in a traditional sense: there was no fixed fraction of students who received any given grade, for example.*

[8] *...except that in the winter of 2020 we abruptly taught the course online for the second half of the semester—an instructional mode that continued through the spring of 2021. In this case we were unable to proctor the assessments, and students self-proctored and submitted their hand-written work online. We also experimented with non-punitive online proctoring support for the credit-bearing assessments. Starting in the fall of 2021 we returned to in person instruction and assessment and discuss further changes to our assessment model in our conclusion.*

midterm and the other a non-comprehensive exam toward the end of the semester. While the exams were in the past 8–12 problems long, with a 90-minute (for midterms) or 120-minute (for the final) time limit, the exams are now about 6 problems long, with a 90 minute time limit. The exams also focus specifically on the learning objectives that we are unable to evaluate easily on the mastery assessments: higher-order problem solving, graph sketching, and the description of mathematics in written form.

The grading scheme for the course then sets thresholds for each letter grade (80 points for an A, 65 for a B, etc.) and a minimum number of points obtained on the mastery assessments (30 for an A or B, 24 for a C, etc.) and the final mastery assessment (9/10 for an A or B, 8/10 for a C, etc.).

Overall, this change in the course appears to have worked very well, even with the disruption caused by the onset of the COVID-19 pandemic midway through the first semester in which it was implemented. The pandemic necessitated an abrupt shift to online learning (with a corresponding and dramatic increase in the support needed by both instructors and students), which undermined our assessment plans for the project. The change to remote learning also makes it difficult to draw quantitative comparisons between semesters with and without mastery assessment: not only did the instructional mode for the course change, but the change and the pandemic itself have had a disproportionately negative impact on many of the populations that are underrepresented in STEM. That said, we have qualitative data that suggest that the changes have had a significant positive impact.

Key among these qualitative measures is that all students in the pilot who put in sufficient work to persist to the end of the semester passed the course. With the previous, exam-centered, assessment we have not been able to make this claim about any semester (even in the absence of a pandemic and its impact on the course). A related feature of the new assessment model is that now students have much better information, from a range of assessments making up almost half the credit in the course, to use when they are making the decision to continue in or to drop the course. In the previous format many students would either drop the course or give up after receiving a low grade on the first midterm, while others would stick with the course because the first midterm was only 25% of their grade—even though from the instructor's perspective it was unlikely that the student could succeed.

The new assessment structure also is better able to deal with exceptions necessitated by student circumstances or other factors external to the course: if a student is unable to complete a mastery assessment because of illness or other factors, it is straightforward to reopen it for them. This is not the case when the preponderance of the assessment is by synchronous, timed exams. The change has an indirect impact on how equitable the course assessment is, in that it makes it easier to create a course policy that is responsive to all students' needs and external constraints.

Anecdotally, instructors reported far fewer complaints from students about the exams, and students—while feeling at times overwhelmed by the work demanded by the mastery assessments—were strongly in favor of the change. Instructors also reported that students gained confidence as they passed mastery assessments. The feeling of accomplishment, that they could do the course work, and that their performance was in their control were all positive changes in student attitude. There is evidence supporting these anecdotal reports: students' persistence, as measured by the number of attempts that they made on each of the assessments, continued at a high level throughout the semester (the average number of attempts per student on the last four assessments was slightly higher than that for the first four). This change is important: when faced with three exams some students felt that their grade was not in their control but would instead depend on what the exam looked like or how the grading scale turned out. This premise carries with it significant negative implications for student learning: for example, rather than truly figuring out a part of a difficult topic, students would either hope it did not come up on the exam or hope that others would also struggle with it so that they could get by on the grading scale. Or they would guess or omit the solution to one part of the topic and bank on losing at most a few points. By contrast, with the mastery assessments students aiming for an A or B in the course can't just skip over a topic, because of the minimum mastery point requirements for the different letter grades. Further, students can explicitly identify the ideas they were struggling with and continue to work on them until they attain mastery. This overall evidence of a transition to a growth mindset is another, though indirect, measure of our potential at supporting underrepresented students, as adoption of growth mindsets in classrooms has been shown to have a positive impact on student success, particularly for groups that are traditionally underrepresented (Hill et al., 2010; Sisk et al., 2018).

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Supporting Underrepresented Minority Students in STEM Through In-Class Peer Tutoring

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Description of the Program

Development of the Program

We will begin with the history of the program. Our institution has four concentrations within the math major, one of which is a Math Education concentration. This is more like a pure math major, and does not include an education dual degree or teaching certification, but it does include one required math tutoring class. This class, Math Education Practicum, is open to students from all concentrations, and it focuses on providing students with practical classroom tutoring experience, alongside the investigation of issues of teaching and learning mathematics. Originally, the student tutors worked in developmental math labs. Organizational restructuring and changes in leadership over the years lead to the eventual removal of these developmental math labs. Placements were required for the math tutors enrolled in the Practicum class. This led to the practice of utilizing the tutors during class time, rather than in an outside of class tutoring lab.

There is a second dimension to the development of this program. In addition to requiring placements for the Math Education majors enrolled in the Practicum class, we required employment for our students funded by the Louis Stokes Alliance for Minority Participation (LSAMP) [IOA-LSAMP NSF grant #HRD 1826864]. At the same time as the developmental math labs were being phased out, we were redefining the scope of student work under the LSAMP grant. Students meeting the criteria were eligible to be paid for tutoring work, and these LSAMP students constituted our second pool of potential in-class peer tutors. To qualify for LSAMP, students must be American citizens or permanent residents, maintain a 3.0 GPA, have declared a major in a STEM field, and be an underrepresented minority (African American, Alaskan Native, American Indian, Hispanic or Pacific Islander). The main objective of HPU's LSAMP is to support Native Hawaiian and other Pacific Islander students.

Current Status of the Program

In the current iteration of this program, students are assigned to work with a math faculty mentor as peer tutors in active learning, or inquiry-based math classrooms. It should be noted that on rare occasions there are some in-class peer tutors working at our institution who come from the Math Practicum pool, who are from groups over-represented in STEM (e.g., Japanese males. However, all LSAMP students, and the vast majority of the non-LSAMP students, are women, Hispanic, African American, Native American, or Native Hawaiian). For example, in 2018, the Math Practicum class had five students enrolled, three of whom were Pacific Islander LSAMP students, one was Hispanic, and the other was international. Another semester the class was over 65% Native Hawaiian. The program as it relates to this article will focus on the use of all student tutors, not exclusively on those from any racial or ethnic category, though as noted above, the majority of our peer tutors belong to groups that are historically underrepresented in STEM.

The author, who oversees the peer tutoring program and serves as the LSAMP Campus Coordinator, would send an annual solicitation to the math faculty, looking for those who wish to support students, and who agree to utilize active learning pedagogy (so that the tutors have work to do during class). Those faculty wishing to supervise and mentor a tutor were provided with one. Student tutors were selected through a formal application process for the LSAMP program, and to be eligible to participate, the student must be from a racial or ethnic group the NSF identifies as being underrepresented in STEM. In addition to the requirements for the grant, the student should have earned a high grade in the class they would be tutoring. Students were trained either through the Practicum class, or by their faculty mentor; oftentimes the tutor already had a relationship with their mentor, and had taken the class they would be tutoring so they were familiar with the material and teaching methodology. The tutors were paid an hourly stipend. The author coordinated the employment with the HR and grants office, and placement with a faculty mentor, who managed the tutor's daily activities and assignments. There are approximately 5–10 student participants in the program per year, where each tutor is able to reach dozens more students through their daily tutoring work.

The tutors worked for several different math instructors, in classes from developmental math and pre-calculus, through mid-level calculus and linear algebra, to upper-level classes like proof writing and abstract algebra. The student tutors met with their faculty mentor prior to the start of the semester to have all expectations and duties

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