Moving beyond gatekeeping: Using data analytics to overcome resistance to pedagogical change

Daniel L Reinholz, Chris Curtis, Niral Shah

To cite this version:
Daniel L Reinholz, Chris Curtis, Niral Shah. Moving beyond gatekeeping: Using data analytics to overcome resistance to pedagogical change. Twelfth Congress of the European Society for Research in Mathematics Education (CERME12), Feb 2022, Bozen-Bolzano, Italy. hal-03747829

HAL Id: hal-03747829
https://hal.science/hal-03747829
Submitted on 8 Aug 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Moving beyond gatekeeping: Using data analytics to overcome resistance to pedagogical change

Daniel L. Reinholz¹, Chris Curtis¹, and Niral Shah²

¹San Diego State University, Department of Mathematics and Statistics, San Diego, USA; daniel.reinholz@sdsu.edu; ccurtis@sdsu.edu

²University of Washington, Learning Sciences & Human Development, Seattle, WA; niral@uw.edu

Postsecondary mathematics education often plays a gatekeeping role in STEM higher education. Accordingly, research highlights the need for pedagogical change to promote more equitable mathematics classrooms. However, mathematics faculty often resist change, grounded in rationalizations such as “math is just hard.” In this manuscript, we offer a concrete approach to overcoming such resistance. The approach uses classroom data generated by the observation tool EQUIP. We provide reflections from one participating mathematics faculty member on his experiences engaging in this process. We discuss implications for using this approach at scale.

Keywords: Change, classroom observation, data, instructional change, pedagogy, reflection.

Introduction

Mathematics is widely recognized as a gatekeeper to higher education, especially within STEM fields (Martin et al., 2010). Cultural narratives position mathematics as largely white, masculine, and able-bodied (Reinholz, 2021). As a result, mathematics plays an integral role in the persistent marginalization of students based on race, gender, disability, and other identities (National Center for Science and Engineering Statistics, 2021). Mathematics instruction is typically guided by a number of purportedly neutral logics, which in fact disproportionally impact students based on their identities (Leyva et al., 2021). Logics include, “mathematics as universal and objective,” “math is challenging,” “some people are simply not math people,” and that the role of mathematics instruction is to “weed out incapable students so the best ones remain” (Reinholz & Dounas-Frazer, 2017; Seymour & Hewitt, 1997). Given that such logics are regularly deployed in mathematics instruction, how can the field make progress towards more equitable and anti-racist teaching practices?

In this manuscript, we offer an approach for making progress despite this seemingly intractable problem (cf. NCSES, 2021). Our approach is organized around classroom observation and data analytics. First, we document concrete events in a context that is relevant to an instructor – their own classroom. Next, we use these as grist for interrogating taken-for-granted cultural logics. To do so, we use the classroom observation tool EQUIP (Reinholz & Shah, 2018), which provides data analytics describing patterns of inequity in classroom participation, disaggregated by social marker identities. By providing such data to an instructor, we first demonstrate concretely how inequities arise in everyday classroom interactions. Next, we work with instructors to change their teaching practices, and accordingly, demonstrate that changing such participation patterns is within an instructor’s locus of control. This serves for the basis for discussions of why such inequities existed.
in the first place, and why they align with what one would expect based on historical patterns of marginalization in mathematics. To illustrate this approach and learning process, we provide reflections from a single mathematics faculty member who participated in an EQUIP learning community in Spring 2020. Our goal is to spur conversations on how this approach can be scaled up and used across contexts.

**Background**

Participation in classroom discussion is highly valued across mathematics education (Hufferd-Ackles et al., 2004). The reason for this focus is that participation in discussion contributes both to learning and identity development for students (Reinholz & Shah, 2018). It follows then, that students who participate are more likely to succeed and persist in mathematics. Yet, simultaneously, research shows that these patterns of participation are inequitable across identities such as race and gender (Ernest et al., 2019; McAfee, 2014). Thus, participation is one concrete site within which inequities arise in the mathematics classroom. Moreover, patterns of participation are relatively easy to capture through classroom observation, and once captured, changing such patterns is within an instructor’s control.

We used EQUIP to capture participation (Reinholz & Shah, 2018). To efficiently facilitate the use of the EQUIP protocol, we used the free, open source and customizable EQUIP web app ([https://www.equip.ninja](https://www.equip.ninja)). EQUIP describes classroom participation at multiple levels – individuals, groups, and the whole class – through a variety of data visualizations. The unit of analysis in EQUIP is a contribution, which consists of a sequence of talk from a single student. Each time a new student talks, a new contribution begins. For each contribution, a coder (in this study, a graduate student observer who was trained to use EQUIP) codes several aspects of the contribution, such as the length (1-4 words, 5-20 words, or 21+ words) and type of student talk (why, how, what, or other), and an instructor’s questions (why, how, what, other, or N/A). Because all these facets of classroom practice are attached to specific students, analytics can be disaggregated at a student level. By including demographic information, a user can then generate analytics about particular student groups (e.g., Black women, Latinx men). The specific demographic categories and codes used can be customized according to the local context. In this way, EQUIP represents a particular methodology for tracking classroom participation, which is instantiated according to local needs.

**Method**

**Participants and Context.** We report on work that took place at a large, research intensive Hispanic Serving Institution (HSI) in the US.¹ Participants were recruited through an open call to the university. The second author of this manuscript (Professor C) participated in a cross-disciplinary learning community during the Spring 2020 semester. During Spring 2020, instruction began in a face-to-face modality, and transitioned online mid-semester in response to the global coronavirus pandemic.

---

¹ HSI is a federal designation that denotes at least 25% of the student population is classified as Hispanic.
The second author is a member of the Mathematics Division, whereas the first author is a member of the Mathematics Education division. This difference in affiliation manifests in a strong difference in professional obligations between the two authors, with the second author expected to publish regularly in highly specialized technical journals, pursue external funding, supervise theses in mathematics research, and promote an overall culture of “competitive” mathematical ability within the department with an eye towards maintaining standing in the larger international research community. This role directly reflects the second author’s educational background and acculturation within mathematics. In large part, the role of the second author then is to find and select the “best” students to follow the same professional trajectory at the second author. This institutional pressure differs from an approach that would instead focus on helping all students succeed as much as possible.

Focal Course. Professor C taught Introductory Real Analysis (also called Advanced Calculus, in the US), which met three times weekly during 50-minute sessions. The student population in this course is diverse in terms of race, gender, and mathematical focus. Some students are focused primarily on becoming mathematics teachers, whereas others are working towards STEM-intensive careers. In either case, Real Analysis is a critical course for all mathematics majors and is seen a difficult course. Students enroll in this course during their 3rd or 4th year, after completing three prerequisite courses. For students transferring from local community colleges, this may be their first mathematics course in a new learning environment. Given all these factors, the student population is very heterogeneous.

There were 33 students in the course (22 women, 11 men). The racial demographics were: 12 White (36%), 5 Asian (15%), 9 Latinx (27%), 1 Pacific Islander (3%), and 6 Unknown (18%). These data were collected from a survey of students, and missing information was filled in based on the instructor’s perceptions (which is the reason for unknown results in the race category). The racial demographics are somewhat less diverse than the campus as a whole. We recognize that instructor perceptions may not always align with student self-identification, but we note that an instructor’s biases are most likely to align with their own perceptions, so they were still useful for an intervention to reduce bias and promote equitable teaching. The gender demographics were notable because 3rd/4th year math courses tend to skew heavily towards men but did not in this case.

On the target campus, the deadline to withdraw from classes is two weeks after the semester begins. Given that this date is so early in the semester, students may realize that the course does not fit into their schedule or work/life balance only after this deadline. As a result, there are sizable populations of students that essentially “drop” the class by ceasing to participate for the majority of the semester. These students can become especially frustrated at their lack of success and finding effective strategies to keep them engaged or get them reengaged in the course is nontrivial.

Design. The six faculty participants in the learning community met on a regular basis (typically every few weeks) to work collaboratively to improve equity in their classrooms. The learning community was organized around iterative reflection cycles. In each cycle: 1) instructors were observed teaching (through a video recording), 2) the teaching was coded and feedback was provided, and 3) there was a feedback meeting to debrief and plan next steps. By including multiple
reflection cycles over the course of a semester, instructors had multiple opportunities to reflect, change practices, and observe changes in the data. There were five debrief meetings throughout the semester. In this manuscript, we focus on a Professor C, who was the only mathematics faculty member in the learning community.

A total of four lessons were video recorded and coded by a graduate student who was trained in the EQUIP protocol. In the beginning of the semester, instruction was recorded in the classroom using a video camera, which was later coded. In the second half of the semester, Zoom virtual meetings were recorded and coded. In the classroom recordings we could only capture whole-class discussions (due to data collection limitations), whereas in the Zoom recordings we captured both whole-class discussions and breakout rooms. Instructional practices were coded along several dimensions, including the length and quality of student talk, and the type of instructor question. The coded data from each observation were provided to Professor C in a written report, which outlined key highlights in the data, as well as possible suggestions for revision to practice. Detailed notes from each meeting and well as records of feedback were retained to support data analysis and interpretation.

**Analyses.** In this brief manuscript, our analyses focus primarily on the Professor C’s reflections (the second author), with some reference to the analytics generated in the process. Prior work has documented changes to instructional practices through EQUIP communities (Reinholz et al., 2019, 2020). Here, our goal is different. We are focused on longer-term changes to an instructor’s logics, and how EQUIP could support such self-reflection.

**Results and Reflections**

**Initial Approaches.** Even though Professor C was a member of the mathematics division, he had a personal commitment to do his own studies of feminist and anti-racist literature. This is somewhat unusual for core mathematics faculty. The impetus for this reading was grounded in his general worldview and attention to equity. This background work provided him with a foundation to start thinking about students’ intersecting identities with varying degrees of existing privilege. However, most of this reading was in more general settings and not specific to mathematics. This also meant that he did not have specific instructional moves that he could apply to mathematics teaching. This was a primary motivation for joining the learning community. While he was aware of issues, he was not sure how to approach solving them. Moreover, he was less aware of how his own demeanor and particularly privileged identity (white, hetero-passing, cis-male) influenced the nature of discussions in his classrooms.

There is a general perception within the department that students should be “mathematically mature” by the time they enrolled in Advanced Calculus. Given these broader narratives within the department (and mathematics writ large), Professor C initially felt that if a student was not “ready” by the time they enrolled, then there was little chance of them doing well. Professor C reflected on this bias of his and its origins in his own educational experience. Even as he questioned his own assumptions, there was still the larger issue of developing effective strategies and alternate pedagogical approaches to help enhance participation and success for all students in his class. One strategy that Professor C did use from the beginning of the semester was breaking students into
groups of 3-4 students who would work collaboratively on problems. A rationale was that “stronger” students would serve as the de facto liaisons with Professor C, providing a kind of cover for students less willing to engage in what had been described as a “coldness”, “lack of patience”, or “condescending attitude” from Professor C (quotes taken from prior student reviews). As we note below, Professor C later came to question this idea of stronger students being the ones to support their peers, and he looked for ways to engage more students directly in the class.

Data Analytics. We begin with data from two of the four EQUIP observations that focused on in-person teaching. Across the two observations, what is perhaps most notable is that 23/33 (70%) of students logged no interaction at all. This issue of such a marked absence of classroom participation then became a topic of focus during the learning community meetings lead by Professor R, which occurred after observations. In addition, of the 35 interactions logged, they were disaggregated by the following racial demographics: 18 White, 14 Unknown, 2 Latinx, and 1 Asian. Thus, while only 36% of the class was White (12/33), 51% of contributions were from White students (18/35). By gender, they were: 11 by men, and 24 by women, which largely matched the class demographics of 11 men and 22 women. This shows that there were clear patterns based on race, but not so much based on gender. Largely underlying these patterns was the fact that 18 of the contributions belonged to just three students (a white man, a white woman, and a woman of unknown race, with 6 contributions each). The fact that a few individual students could dominate the discussion became a focal point of discussion within the learning community. Notably, the presence of a dominant subset of students was consistent with the notion of “de facto liaisons” to the professor. What is important from the perspective of anti-racist teaching, is recognizing that this small subset of dominant students often belongs to privileged racial groups in the discipline, and thus better distributing their participation would be a move towards racial equity.

The final two observations were conducted during virtual teaching. Whereas the initial observations focused on whole-class discussions, the primary teaching method in the online setting was through breakouts, which were easy to code using the virtual medium. Across these observations, there were 61 contributions logged, from 18/33 students (55%). The breakdown of contributions by race was: 18 White, 27 Unknown, 11 Latinx, and 5 Asian. By gender, it was 13 by men, and 48 by women. It’s notable that the patterns of participation were more equitably distributed by race, with far more contributions from Latinx and Asian students than in the original two observations. This may partially be explained by the closer interactions between instructor and student being documented in breakout rooms. In addition, we suspect that strategies developed (e.g., using student names directly) provided Professor C with tools to engage more students and increase racial equity. This allowed him to shift the patterns that were present in the first two observations.

Transformed Practices. By the end of the semester, through looking at the EQUIP data and interacting and receiving feedback from the other faculty and classroom monitors in the discussion group, Professor C began to develop a better sense of the need to use more personally identifying features of students, such as first names, when engaging in classroom/Zoom discussions. These was particularly profound in a subject matter like mathematics, which is typically seen as objective and depersonalized. Likewise, he developed an emerging sense of trying to ask questions related to tasks at hand that were not only directed towards getting the answer, such as “What were some
difficulties that came up while trying to solve problems?” or “What was the most interesting part of the discussion for you?” to give more students an opportunity to participate and thereby integrate themselves into the classroom dynamic. This was important because mathematics is usually seen as right or wrong, and the goal is to get the right answer as quickly as possible. Changes in questions can be seen in Table 1.
There are two notable shifts. In the first two sessions, 60% of questions were coded as N/A, which meant students shouted out answers without a specific question from the instructor. This decreased dramatically in the Zoom sessions, reflecting the instructor’s increased role in managing the discussion. This is important, because prior EQUIP work has shown that when students simply shout out answers, dominant students tend to dominate the discussion. Also, there was a larger increase in “other” questions (from 20% to 62%), reflecting the alternative types of process questions the instructor was asking.

Overall, Professor C developed a much greater sense of and strategies for addressing the need to keep as many students as possible actively engaged in classroom dynamics as a means towards enhancing equity in the classroom. He recognized that without such strategies, students who were from dominant racial and gender groups were most likely to dominate. Thus, these general strategies of involving students who may not be participating are an important step towards being able to monitor racial and gender equity in an ongoing way. In future classes, if similar patterns become visible, Professor C was now equipped to utilize strategies to engage individual students within particular identity groups to better bring them into the classroom discussions.

Reflecting One Year Later. Since the time Professor C participated, he taught Calculus 2 via Zoom to 130 students. Admittedly, the online environment did not readily facilitate implementation of the techniques explored and cultivated in the Spring 2020 EQUIP discussion group. However, he will soon take over the role of coordinator for the course and will be responsible for the educational experience of approximately 450 students. This involves Professor C coordinating across two to three Instructors as well as seven to eight Teaching Assistants. Having seen the inadequacies of online instruction for what is for many students an especially demanding and stressful course (e.g., in limiting meaningful interactions between instructors and their students), from his experience with EQUIP, he is keenly aware of the need for implementing strategies to keep students engaged in as equitable of a fashion as possible, and that doing so is critical to student success. This will include

1. Engaging in discussion with Teaching Assistants and Instructors about the need to encourage different groups of students to participate in class and to find novel strategies to facilitate that participation. Such strategies include soliciting replies to questions which do not directly deal with the mathematical problems at hand, or explicitly finding ways to elevate the voices of students that otherwise might be quiet.

2. Developing the capacity for Teaching Assistants and Instructors to personalize interactions using names or other means of identification to reinforce students’ personal involvement and investment in the classroom environment. For students who might not feel as though they belong “by default,” instructors need mechanisms to explicitly create a sense of belonging.
3. Facilitating conversations among Teaching Assistants and Instructors about the role implicit bias may be playing in their teaching and ways in which they could work to address said bias. This is especially salient with regards to social markers such as race and gender, which are visible in the classroom and are also known sites of inequity in mathematics education.

These implications for practice and coordinating the learning experiences of students were informed by Professor C’s opportunity to reflect on his data and his own biases in teaching with EQUIP data. Outside of the classroom, Professor C also reflects on the role of larger movements. For example, in response to the Black Lives Matter movement as well several other social justice movements involving Latinx, Asian, and Native American peoples, Professor C views part of his role as a tenured member of his department and as a course coordinator as involving anti-racist work, which he views as essential to ensuring equitable access to success in STEM. His participation with EQUIP provided invaluable tools and insights for performing this kind of action in concrete ways in the classroom. It helped bridge the gap from theory to practice. In this way, although the EQUIP community was ostensibly focused on classroom teaching, it provided impetus, support, and strategies that could be transferred to other venues such as course coordinating, departmental policy, and civic engagement.

**Discussion**

Mathematics long has a history of gatekeeping and weeding out students. There is also a history of divide between Mathematics and Mathematics Education faculty within mathematics departments. In this paper, we share preliminary work that aims to bridge both divides, by applying mathematics education techniques to teaching mathematics, and by building a meaningful partnership from faculty in both branches of the department. The approach is grounded in data. Especially for faculty working in Applied Mathematics, there is a facility and disposition towards using data that makes the approach particularly appealing.

Here we illustrate how the data were helpful in overcoming inertia associated with the weed-out culture of mathematics. Initially, Professor C was coming from the perspective that some students simply would not succeed, so it was important to center efforts on those who would most likely succeed. Working with concrete data and a supportive community, this shifted over time to building greater awareness of the sociological aspects of teaching and how to develop concrete strategies for bringing more students meaningfully into the mathematical discussions.

This preliminary work has the potential to scale. Given that EQUIP is a fully customizable tool, it can be used to consider equity issues relevant to any context. While some of the issues related to race are specific to the US context, racial dynamics can play out differently in other places, and there are other forms of hierarchy (e.g., language, immigration status). Another issue to consider in scaling is the process of observing and facilitating professional learning. As the work continues, we will explore further models for self-study and self-reflection, which provide a greater variety of opportunities.
Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. 1943146.

References


