# SOCIAL JUSTICE PEDAGOGIES

## 1. Stopped for Effect: The Urgency of Active Learning

We would be remiss to fail to include a section on pedagogies that have been repeatedly shown in studies and large meta-analyses to improve learning for all students, particularly minoritized students. In a meta-analysis of 225 studies on STEM course performance, Freeman *et al.* (2014) showed that evidence-based pedagogies which involve student participation, commonly but increasingly vaguely referred to as "active learning", improved student performance by half a letter grade, while lecturing results in a 55% increase in student failure rates compared to active learning and the odds ratio for failing was 1.95 under traditional lecturing (what might better be called "continuous exposition by the teacher"). Famously, the study concludes that

> If the experiments analyzed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit—meaning that enrolling patients in the control condition might be discontinued because the treatment being tested was clearly more beneficial. For example, a recent analysis of 143 randomized controlled medical trials that were stopped for benefit found that they had a median relative risk of 0.52, with a range of 0.22 to 0.66. In addition, best-practice directives suggest that data management committees may allow such studies to stop for benefit if interim analyses have large sample sizes and $P$ values under 0.001. Both criteria were met for failure rates in the education studies we analyzed: The average relative risk was 0.64 and the $P$ value on the overall odds ratio was $<< 0.001$.

Additionally, the benefits of active learning are felt disproportionately by students from groups underrepresented in STEM. A meta-analysis of many studies on student exam scores and failure rates (Theobald et al. 2020) found that "achievement gaps" in exam scores were decreased by 33% under active learning, while gaps in passing rates decreased by 45%. The study emphasizes the urgency of adopting inclusive teaching practices:

> Underrepresentation in STEM is primarily due to attrition. Underrepresented minority (URM) students in the United States, for example, start college with the same level of interest in STEM majors as their overrepresented peers, but 6-y STEM completion rates drop from 52% for Asian Americans and 43% for Caucasians to 22% for African Americans, 29% for Latinx, and 25% for Native Americans. Disparities in STEM degree attainment are also pronounced for low-income versus higher-income students.

Importantly, improvements in performance were only observed for students that participated in "high-intensity active learning"—meaning those in which a great deal of class time involved students engaged in activities designed to help them construct their own knowledge. Per the Discussion section:

> We propose that two key elements are required to design and implement STEM courses that reduce, eliminate, or reverse achievement gaps: deliberate practice and a culture of inclusion. Deliberate practice emphasizes 1) extensive and highly focused efforts geared toward improving performance—meaning that students work hard on relevant tasks, 2) scaffolded exercises designed to address specific deficits in understanding or skills, 3) immediate feedback, and 4) repetition (49). These are all facets of evidence-based best practice in active learning (38, 50, 51). Equally important, inclusive teaching emphasizes treating students with dignity and respect (52), communicating confidence in students' ability to meet high standards (53), and demonstrating a genuine interest in students' intellectual and personal growth and success (54, 55).

## 2. So What Is "Active Learning"?

There is no single agreed-upon definition of "active learning". However, certain pedagogies and interventions show up repeatedly in the literature as particularly effective. I am indebted to Josh Eyler and the Rice University Center for Teaching Excellence in my own journey to learn and implement evidence-based pedagogies. The book *What the Best College Teachers Do* provides a digestible summary, as does Josh's book *How Humans Learn.* The ideas below are heavily influenced by each of these sources as well as my own experience.

First and foremost, the best teachers are empathetic and inclusive. In particular, they believe that every student can learn, and that learning cannot happen with "productive failure". Grounded in this philosophy, effective teachers make space for all students to try and fail and try again in low-stakes environments. This often involves allowing students to correct assignments/exams and certainly not repeatedly giving high-stakes assessments without providing time for students to reflect and correct mistakes.

In pedagogies such as *inquiry-based learning* in mathematics and POGIL in computer science, a mixture of instructor feedback and peer instruction is involved. Many inquiry-based math courses involve students presenting on the board to the rest of the class, after which respectful student feedback is solicited. Peer instruction helps avoid the *expert blind spot,* when instructors forget what was most confusing in their own learning process after years of professional experience and fail to emphasize potential problem areas to students.

Students bring their own prior knowledge into every course they take. In order to promote learning–which necessitates a change in mental models–it's important to invest time in getting to know students' schemata related to your subject and meet students where they are. This often involves *metacognition*, or thinking about thinking, both modeled by the instructor ("what do you notice? What do you wonder?") and encouraged on assignments (e.g. through required reflections when students revise and resubmit assignments). In math, this sometimes involves *teaching the paradoxes*–as mathematicians, we value paradox for the inaccuries it points out in our own thinking, and it's worth passing this tool on to our students.

Contemporary definitions of active learning are rooted in the educational theory of *constructivism*, in which we all build our own knowledge and the best way to learn is to be handed the building blocks. Most educational researchers agree that some level of instructor guidance is necessary for students to learn to put together the building blocks and build theoretical structures, and even what is thankfully less frequently called the "full Moore method" incorporates some level of instructor guidance, at least when providing feedback on proofs.

Increasingly, researchers emphasize that *lecturing* does not in itself constitute bad pedagogy; indeed, the frequency and level of interactivity of a lecture is essential in determining how effective it is. *Mini-lectures* of around 10 minutes at a time, interspersed with group work on authentic, challenging problems, can be an effective course structure. Mini-lectures are a particularly good place to introduce definitions or foundational theorems, as well as to offer students a "guided tour" of more difficult topics. Making time for students to ask questions during lectures–and even calling on students or groups to share their responses to a lecture–help engage students and facilitate learning.