

Why We Teach a Groups-Based Problem-Solving Math Curriculum at Bellarmine:

From “Hitting the Wall” to College and Career Readiness

Over the years, we Bellarmine math teachers have seen many students come up through the math program only to hit a wall in Precalculus. Increasingly, in recent years, many were starting to hit the wall even earlier, in Algebra 2. Frustrated and puzzled, we identified a number of possible reasons why these students struggled with the progression to upper levels of math. We made adjustments accordingly to things like curriculum content, level of rigor, availability of student support, etc., but the problem persisted and only seemed to be get worse.

After additional discussion and research, we realized there was a structural issue in the traditional high school math curriculum which was contributing to the problem. Specifically, there was a significant difference between what students were asked to do in our lower division, core courses, compared to what students needed for success in our upper division courses, which left students unprepared for courses like Precalculus and Calculus.

Math as Recipe-Following

Traditionally, math at the lower levels has been taught as a series of procedures. Typically, students are sitting in rows, silently taking notes as a teacher presents a problem and a procedure for a solution. The teacher solves several examples and then the class is given 10-20 very similar problems to allow them to practice the procedure at home. The next day the teacher answers student questions (usually about the procedure, not about the concepts behind the procedure) and the teacher then starts the next lesson about the next procedure. Quizzes and exams consist of a collection of problems almost identical to the ones the students have already practiced so the students can demonstrate mastery of the procedures. This method of instruction has been used not only in lower-division high school courses, but often in middle and elementary schools as well.

The type of instruction described above teaches students that math is simply a collection of short, predictable, closed-ended problems and the key to success is to memorize procedures. Understanding anything deeper, or even why the procedures work isn't necessary. This is all very comfortable for teachers and students, and it certainly rewards organization and diligence on the part of the student. But it also sets up any college-bound math student for frustration when he or she reaches upper-division high school math courses.

Tell Me Which Formula to Use

Somewhere between Algebra 2 and Precalculus, a student can no longer learn math as a series of procedures or recipes to follow. This is because at these levels, the problems are multidimensional and require students to think flexibly and visually. There are so many moving parts to problems at this level that students must be making sense of the math in order to solve them. Procedures will certainly help but the student needs to know which ones to apply and why. This requires higher-level problem-solving

and analytical skills which students in a procedure-heavy curriculum never develop. They may be equipped with many procedures in their toolkit but when faced with a Precalculus problem to analyze and solve they have no idea even where to start.

Another characteristic of upper division math is that the problem-solving is more challenging and takes longer. As the analysis becomes more complex and multidimensional, it's more often the case that a first attempt at a solution does not work and a second attempt is required. A student who has only seen short, predictable, closed-ended problems that are quickly solved by applying a formulaic procedure hasn't developed the resilience and perseverance to respond to struggle by trying again in a different way or by making use of resources available to them. They've been conditioned to expect that they should be able to solve all math problems quickly and when that doesn't happen they are more likely to get frustrated and give up.

College and Career Readiness Requires Problem-Solving Skills

These problems are not unique to Bellarmine but we have certainly seen our share of students “hit the wall” as they enter upper division math. We realized that because all of our students are college-bound, we needed a different approach in our core courses, which would prepare students, not only for our upper-division courses, but also for college and career. Several years ago, we began work to roll in a new curriculum, College Preparatory Math (CPM), that pushes more problem-solving and sense-making into our lower division, “core” math courses: Algebra 1, Geometry, Algebra 2. The curriculum content of these courses did not change dramatically, but the nature of classroom activity changed to allow students to develop the skills they need at the higher levels. Procedural fluency is still an important goal, but it is achieved through sense-making and problem-solving—much like our upper-division courses.

For example, our Algebra 1 classroom looks very different from the traditional model. It resembles a “math workshop,” in which students are seated in groups (as is the case with most of our upper division courses) and asked to problem-solve together under the guidance of a teacher. The problems they solve are not short, closed problems, but rather they are open, discussion-worthy problems. These problems ask students not only to draw on their previous knowledge, but also to think flexibly about the math. Additionally, we ask students to discuss and debate their approaches to each problem. This discussion deepens understanding and teaches students that there often are multiple ways to think about a problem. This in turn encourages students to make connections between ideas and to think more flexibly about math.

To be clear, this is not a “discovery” method of learning or a “hands-off” method of teaching. Certainly, students very often make new connections and discover new ways of looking at the math, but the teacher is not relying on students to teach themselves. The teacher is engaged in guiding the problem-solving and helping to move student discussions forward. The teacher also uses direct instruction when appropriate and he or she closes each day with a summary of the key concepts of the lesson. Most importantly, the teacher ensures students have the tools they need to successfully engage with a problem.

Furthermore, the solutions require more than a rote application of a procedure. They require analysis, discussion, and often an application of several ideas students have learned before. The teacher will provide guiding questions and suggest strategies, particularly when students reach an impasse and need help thinking differently about a problem. But the objective is always to provide an opportunity for students to make connections on their own, which in turn helps them to develop key analytical and problem-solving skills.

The Role of Struggle in Math and Learning How to Navigate Through It

This of course means struggle is involved because problem-solving and skills development both involve struggle. We understand this might frustrate some students and we empathize with them. Our intent is certainly not to frustrate, but neither is it to offer a struggle-free experience. We teach our students that struggle is not a sign of weakness or inability but rather a sign of growth and learning. Despite popular myth, successful people do struggle. We try hard to reassure students they will not be left to sink when they don't understand, we are there to support them and to provide strategies for moving forward. Along with this reassurance comes the message that the more comfortable students are with struggle and the more open they are to challenge, the more successful they will become—not just in math but in college, career, and life as well.

Developing Problem Solvers...with Support Along the Way

The most successful students persevere and develop strategies for using resources available to them to help navigate through struggle. This is what problem-solvers do and we believe **every** Bellarmine student can develop good problem-solving skills and succeed in math. Central to the mission of Bellarmine math teachers is to make students aware of those resources and to help them develop and implement good strategies for navigating through the challenges they face. As Columbia University math professor and New York Times columnist Steven Strogatz states, *“It’s crucial to help our students realize that it’s fine to get stuck – after all, the life of a professional mathematician (or any other creative person) is about being stuck nearly all the time! It’s how you get past being stuck that matters. And that’s one of the most valuable lessons that math has to offer.”*

As we move deeper into the 21st century, college and career readiness in math increasingly means the development of problem-solving, sense-making, and analytical skills, not just procedural fluency. In the process, there are also valuable lessons in persistence, resilience, and resourcefulness to learn. The fulfilling jobs of the future will be filled by problem-solvers—people who are excited by new challenges and who are willing to work through them. We believe a curriculum that asks our students to become problem-solvers from the start builds a stronger foundation and will give them a better chance to thrive, not only in our upper division math courses but also in college and beyond.