



An Up-Close Look at Student-Centered Math Teaching



A Study of Highly Regarded High School Teachers and Their Students

EXECUTIVE SUMMARY
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About Nellie Mae Education Foundation

The Nellie Mae Education Foundation is the largest philanthropic organization in New England that focuses exclusively on education. The Foundation supports the promotion and integration of student-centered approaches to learning at the middle and high school levels across New England—where learning is personalized; learning is competency-based; learning takes place anytime, anywhere; and students exert ownership over their own learning. To elevate student-centered approaches, the Foundation utilizes a four-part strategy that focuses on: building educator ownership, understanding and capacity; advancing quality and rigor of SCL practices; developing effective systems designs; and building public understanding and demand. Since 1998, the Foundation has distributed over \$170 million in grants. For more information about the Nellie Mae Education Foundation, visit www.nmefoundation.org.

About American Institutes for Research

Established in 1946, with headquarters in Washington, D.C., the American Institutes for Research (AIR) is a nonpartisan, not-for-profit organization that conducts behavioral and social science research and delivers technical assistance both domestically and internationally in the areas of health, education, and workforce productivity. For more information, visit www.air.org.



EXECUTIVE SUMMARY

Today, far too many students see mathematics as a subject to be endured, rather than a subject of real-world importance and personal value. That doesn't have to be the case. When teachers use student-centered techniques to engage students in more active and authentic ways, they can transform math classrooms into lively learning environments in which students take charge of their own learning, collaborate with others, persist in solving complex problems, and make meaningful connections to the world around them. Through such experiences, students may come to appreciate mathematics as a discipline that enriches their lives and their understanding of the world.

While a growing body of research supports many of the principles of student-centered instruction, there is still a great deal to learn about how such approaches enhance student learning in mathematics. Recent calls for strengthening the STEM workforce and for more rigorous K-12 standards via the Common Core State Standards have placed increased emphasis on developing higher-order thinking and problem-solving skills in high school mathematics, heightening the need for more information about how teachers can effectively engage students with math content.

The American Institutes of Research (AIR), with support from the Nellie Mae Education Foundation, conducted a study of highly regarded high school math teachers to expand the research base in two important ways. First, rather than assuming student-centered instruction is a monolithic construct, the team used a case study approach to provide rich descriptions of how the approach plays out in several classrooms, taking into account how teachers' personal philosophy and the school's instructional context might influence their practice. The case study also provided insights into students' perspectives on different approaches to mathematics instruction. Second, the researchers look across a larger sample of classrooms to determine the effects of varying degrees of student-centeredness on students' engagement with learning and their problem-solving skills.

This brief offers highlights from the study's design and findings. Readers are encouraged to access the full paper for more details.

STUDENT-CENTERED INSTRUCTION IN THE MATHEMATICS CLASSROOM

The term student-centered does not refer to a single instructional method. Rather, student-centered instruction consists of an array of complementary approaches to teaching and learning, drawing from multiple theories and trends in education. While student-centered learning can be described in a number of different ways, the Nellie Mae Education Foundation focuses on the following four tenets:

Learning is Personalized: Personalized learning recognizes that students engage in different ways and in different places.

Learning is Competency-Based: Students move ahead based primarily on demonstrating key learning milestones along the path to mastery of core competencies and bodies of knowledge (as defined in deeper learning).

Learning Takes Place Anytime, Anywhere: The school's walls are permeable – learning is not restricted to the classroom.

Students Exert Ownership Over Their Learning: Student-centered learning engages students in their own success and incorporates their interests into the learning process. Students take increasing responsibility for their own learning, using strategies for self-regulation when necessary.

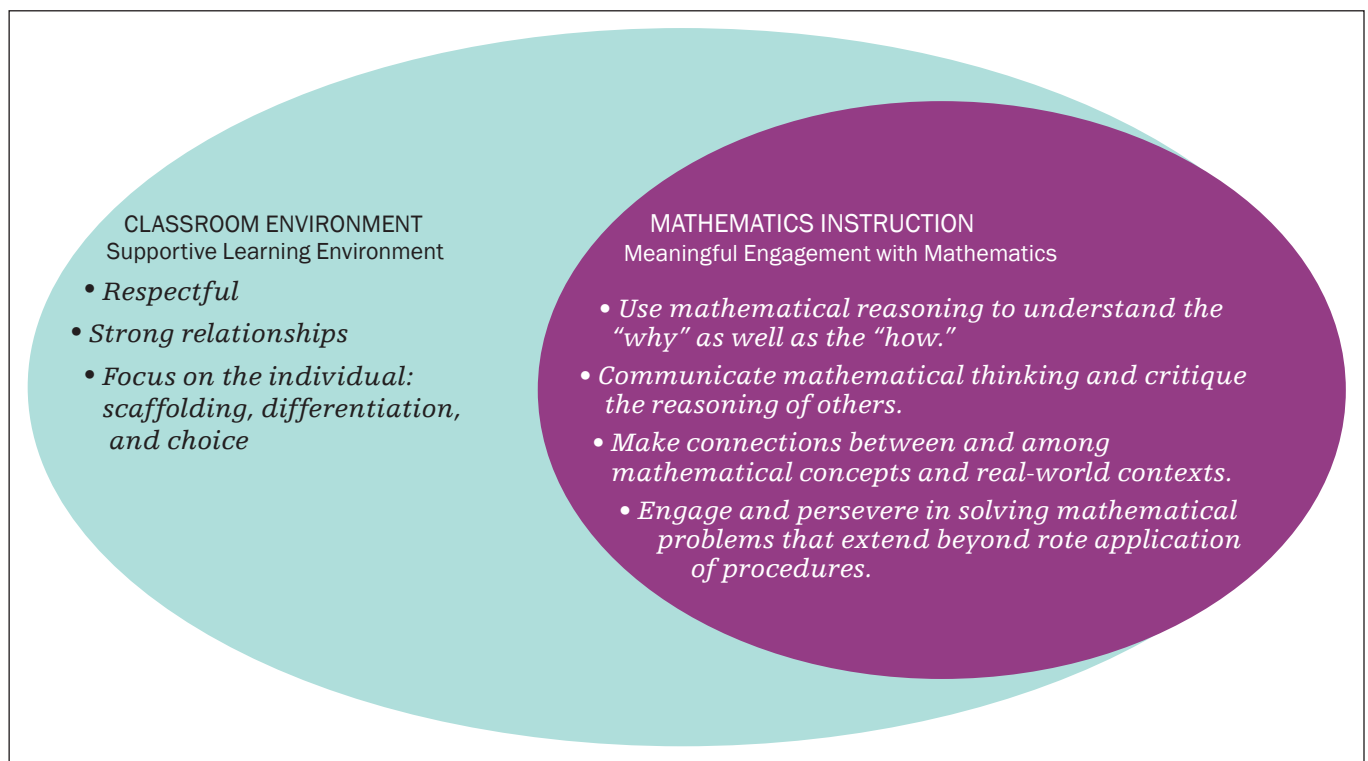
This study was not designed to explicitly address each of these general tenets of student-centered learning, but several of these principles are explored. For example, most, if not all, of the study's sample of highly regarded teachers recognized that their students learn differently and encouraged their students to build on their successes. The main contribution of the study, however, is to explore aspects of student-centered instruction that are specific to the teaching and learning of mathematics. To guide this work, the researchers developed an analytic framework with four types of learning opportunities in mathematics. In student-centered mathematics learning environments, students have meaningful opportunities to:

- Use mathematical reasoning to understand the “why” as well as the “how.”
- Communicate their thinking and critique the reasoning of others.
- Make connections between and among mathematical concepts and real-world concepts.
- Engage and persevere in solving complex mathematical problems.

The researchers applied this framework to examine student-centered instruction in seven case study classrooms, with particular attention to two common phases of math lessons: 1) the development of new math content, and 2) reinforcement of prior learning (see sidebar for more information on the Case Study data and methods). In addition, the research team used a larger sample (22 teachers) to examine the relationship between student-centered instruction and student engagement and problem solving skills. The relationships were based on a composite measure of student-centered instruction constructed from study data. (see sidebar).

The study draws conclusions based on a wide range of data sources, including those very close to the classroom itself (e.g., videos, assignments). The group of highly regarded teachers that participated in the study included those who implemented student-centered approaches to varying degrees and in different ways. Therefore, this research goes beyond the simpler question often posed, “Do student-centered approaches to teaching work?” to more important yet nuanced ones: “Among highly regarded teachers, what are different ways that student-centered approaches are implemented?” “Are there differences in student outcomes associated with the degree to which students’ classrooms exhibited student-centered instruction?”

Characteristics of Student-Centered Mathematics Classrooms



STUDY DESIGN

The study examined the practice of 22 highly regarded mathematics teachers from a range of high schools in the six New England states and New York. The study team solicited nominations of well-regarded teachers. Interested applicants (34 in all) then submitted an application, participated in an interview, and were each evaluated by an instructional leader familiar with their instructional style and general effectiveness. Case study applicants were also observed by a member of the research team. The research team used these data to select a group of teachers who represented a mix of traditional and student-centered approaches.

CASE STUDY

Sample:

- 7 teachers
- 4 more traditional
- 3 more student-centered

Data Sources:

- videos of lessons
- weekly instructional logs
- teacher interviews
- student focus groups

QUANTITATIVE STUDY

Sample:

- 22 teachers (including the 7 from the case study); 11 more traditional and 11 more student-centered; one target class per teacher

Data sources/measures:

- administrative records (student demographics and prior achievement)
- teacher survey
- student survey
- sample challenging assignments
- student problem-solving assessment (PISA items)
- composite measure of student-centered instruction (teacher survey and assignments)

Analysis:

- used a linear mixed model to measure students' engagement
- used a value-added model to measure problem-solving abilities

FINDINGS

The study produced rich classroom vignettes, nuanced perspectives from teachers and their students, and quantitative data about the effects of different teaching approaches.

Student Outcomes

Students in math classrooms led by highly regarded teachers feel very positively about their teacher and the class. However, students with highly regarded teachers who implement more student-centered approaches to math instruction report that they find the content more interesting and meaningful.

Because the study sample included only highly regarded teachers, it is not surprising that students felt very positively about their experiences across all of the case study classrooms, regardless of instructional approach. Students noted that their teachers were organized and went out of their way to be supportive and help them feel successful. Students assigned to teachers who were more student-centered in their approach found even more to appreciate. They reported finding the content interesting and meaningful. Some said that they had grown to love mathematics over the course of a year with that teacher.

Students in more student-centered math classrooms report being more engaged in how much they are learning and how interested they are in the material, compared to students in less student-centered classrooms.

For the 22 classes participating in the quantitative study, the researchers used teacher survey data and sample assignments to create a composite measure of student-centered practice. This continuous measure was used to determine the relationship between student-centered math instruction and student engagement. The engagement measure was drawn from survey items in which students described the extent to which they were learning and their level of interest and motivation in class.

Students in more student-centered math classrooms showed higher growth on a test of problem-solving skills than students in less student-centered classrooms.

The researchers created an assessment comprised of publicly released items from the Programme for International Student Assessment (PISA) to measure problem-solving skills. Using the study's composite measure of student-centered instruction in a value-added framework, there was a significant positive relationship between students in more student-centered classrooms and performance on this assessment.

Classroom Approaches

The researchers began by looking at highly regarded teachers sorted into “student-centered” and “non-student centered” groups, but found that nearly all of these case study teachers used some student-centered practices; the variation was the extent to which they utilized student-centered math instruction. They found that:

- Nearly all highly regarded teachers employ student-centered practices at times.
- Teachers who implement student-centered approaches the most consistently believe in the importance of student-centered approaches.
- Student-centered math instruction allows for strong student contribution, encourages active student exploration, uses problems that require students to think critically and communicate their thinking, and asks students to explain the “why” of their answers.

At the same time, all of the teachers exhibited the characteristics of exemplary teaching, including having strong relationships with students and maintaining a well-organized, respectful classroom.

Teacher-led, whole-class discussion was the most common structure observed during the development phase of lessons, but teachers varied in the degree to which they engaged students in these discussions. Some teachers directed the discussions heavily, while others used exploratory activities and open-ended questions to elicit stronger student contribution. During the reinforcement phase of instruction, teachers also differed in the types of tasks they assigned. Some assigned problems that required rote application of procedures, while others used problems that required students to reason, think critically, and communicate their thinking. Tasks varied in the degree to which they required students to communicate about their reasoning.

Teachers who implemented student-centered approaches more regularly attested to the importance of providing students with opportunities to explore, communicate, and reason in mathematics. Teachers who implemented student-centered approaches less regularly than traditional approaches spoke about the importance of structure and usefulness of direct instruction.

Table 1 below offers a summary of some of the student-centered instructional “moves” that researchers observed during class discussions and in assignments. The full report includes detailed classroom vignettes that elaborate on how these constructs play out in different classrooms.

Summary of Student-Centered Learning Practices of Teachers

SUMMARY OF STUDENT-CENTERED INSTRUCTIONAL PRACTICES OF TEACHERS
Orchestration of Discussion
<ul style="list-style-type: none">• Focus on the “why” as well as the “how.”• Encourage students to justify and explain their solution strategies.• Encourage students to critique the mathematical reasoning of others.• Support students by advancing, but not taking over, their thinking as they engage in productive struggle with mathematics.• Elicit and make connections between different mathematical ideas and/or approaches to the same problem.
Instructional Tasks
<ul style="list-style-type: none">• Focus on the “why” as well as the “how.”• Allow for multiple entry points and solution methods.• Challenge students to reason about mathematics by looking for patterns, making conjectures, conducting explorations, examining connections between and among mathematical concepts, and justifying mathematical solutions.• Make explicit the connections between mathematics and real-life experiences.• Encourage the use of different tools, including technology, to explore mathematics and solve mathematics problems.• Provide collaborative opportunities for students to communicate about and critique each other’s mathematical reasoning.

The Larger School Context

Although the sample size was small, the case study also revealed that, while teachers' philosophies of math teaching and learning matter, the larger school context can influence the extent of student-centered practices in the classroom.

- Teachers who implement student-centered approaches more regularly worked in schools that focused on preparing students for a variety of future pathways.
- Classrooms that emphasized exploratory learning were situated in schools where teachers have both flexibility in lesson design and access to needed materials.

In contrast to teachers who implemented more traditional approaches, teachers who implemented more student-centered approaches tended to describe their school environments as focusing on preparing students for a variety of pathways and that emphasized a broad set of life skills, not just test scores.

There also seemed to be a connection between the curriculum resources teachers had at their disposal and the ways in which they taught. Three of the four teachers who implemented more traditional approaches used a traditional textbook, and the teacher who employed student-centered approaches almost exclusively used a textbook full of exploratory activities and complex problems. The two teachers who implemented a blend of traditional and student-centered approaches used both types of texts.

CONCLUSION AND IMPLICATIONS

While based on a relatively small sample of teachers in one region of the country (New England), the study offers at least four concrete implications for policymakers and practitioners interested in promoting student-centered instruction in mathematics.

Students can benefit from student-centered approaches to math in ways that matter. Skills such as problem-solving have been identified as key to college and career readiness, and assessments indicate that they are sorely lacking in many U.S. students today. Traits such as engagement are critical to promoting long-term student achievement in all subjects, especially those most dependent on cumulative learning of material, such as math and science.

Highly abstract mathematical concepts can be presented in student-centered ways, with positive outcomes for students. While some suggest that learning advanced math topics requires a more traditional instructional approach, this study captures several high-quality student-centered alternatives.

A more fine-grained definition of student-centered mathematics instruction is now available. Many teachers may not have an accurate perception of their own practice or know what it would take to become more student-centered. The framework used in this study may help clarify how student-centered instruction manifests in secondary mathematics classrooms, providing several starting points for teachers interested in moving in this direction.

Teaching philosophy and instructional context may affect how strongly and consistently teachers enact student-centered approaches. These factors should be considered when designing professional development intended to promote student-centered instruction. As educators across the country seek new methods for engaging high school students deeply in mathematics and helping them master sophisticated problem-solving skills, student-centered instruction emerges as a promising approach and one worthy of continued investigation. ■■■

