

A woman with dark hair and a colorful beaded necklace is looking up at a chalkboard. The chalkboard is filled with mathematical equations and diagrams, including a large number '8' and various algebraic expressions. The scene is set in a classroom or lecture hall.

Student-Centered High School Math Teaching: An Up-Close Look

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Student-Centered High School Math Teaching: An Up-Close Look

Education Week Webinar

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2 to 3 p.m. ET

Welcome

Kerstin Le Floch, Managing Researcher, AIR



Study Support

- Nellie Mae Education Foundation supported the study; conducted by American Institutes for Research.
 - AIR research team: Kirk Walters, Toni Smith, Steve Leinwand, Wendy Surr, Abigail Stein, Paul Bailey
- Link to the full report:
 - <http://tinyurl.com/p2kr2z8>
- For more information about both organizations:
 - www.nmefoundation.org.
 - www.air.org

Agenda



Topic	Presenter
Study Rationale & Design	Kirk Walters, Principal Researcher, AIR
Study Framework	Toni Smith, Senior Researcher, AIR
Case Study Findings	Toni Smith, AIR
Quantitative Findings	Kirk Walters, AIR
Practitioner Reactions	Joanna Burt-Kinderman, Math Coach, Pocahontas Schools, WV
Discussion	All



Today's Goals

- To describe the design and key findings from a study of student-centered high school math teaching
- To gather feedback from practitioners about implications from the study to their ongoing work
- To discuss directions for future research

Study Rationale & Design

Kirk Walters, Principal Investigator



Student-centered teaching

- Broad construct
- Study focuses on instructional opportunities that promote active student engagement in learning mathematics
 - Informed from prior research in math education over past 25 years (e.g., NCTM Standards, Adding It Up, Common Core)
- Full framework described in next section



Why this study?

- 21st century, STEM-driven economy demands workers who can solve complex problems, work together and communicate
- Student-centered math instruction considered promising but not well understood
 - Earlier SC reforms haven't been fully successful
- High school teachers may be less open to student-centered approaches
 - Evidence base especially thin at the high school level



Highly-Regarded Teachers

- Strong reputations of helping students succeed
 - Confirmed by referrals, interviews, observations
- Maintained supportive learning environments
- Had different types of math teaching approaches



Research Questions

1. What are different ways in which highly regarded high school mathematics teachers implement student-centered instructional practices?
 - Role of teaching philosophy and instructional environment
 - Student perceptions of different types of approaches
2. Are there differences in student engagement and problem-solving skills that are associated with the degree to which student-centered instructional practices are implemented?

Design



- Mixed methods design involving sample of 22 highly-regarded teachers in New England and New York
- Case study (7 teachers) designed to answer first research question
- Quantitative study (7 case study teachers + 15 non-case study teachers) designed to answer second research question



Sample

- Among study's 22 teachers, 11 were initially identified as more traditional and 11 as more student-centered
- Identification measures included surveys, instructional leader referrals & observations (case study candidates)





Sample

Schools

- Urbanicity: ~50% rural, ~25% urban, ~25% suburban
- Poverty: ~30% FRPL rate

Teachers

- Experience: ~70% had 11+ years of experience
- Gender breakdown: ~75% female, ~25% male

Study Framework

Toni Smith, Project Director



Rationale

- “Student-centered” refers to an array of instructional approaches
- We were interested the features of student-centered instruction that focus on mathematical activity
- We developed a framework that distinguished between features of student-centered instruction that apply to
 - The general classroom environment
 - The way in which students interact with the mathematics



Classroom Environment

Supportive Learning Environment

- Respectful
- Strong relationships
- Focus on the individual – scaffolding, differentiation and choice



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Mathematics Instruction

Meaningful Engagement with Mathematics

- Use mathematical reasoning to understand the “why” as well as the “how”
- Communicate mathematical thinking and critique the reasoning of others
- Make connections between and among mathematical concepts and real-world contexts
- Engage and persevere in solving mathematical problems that extend beyond rote application of procedures

Case Study Findings

Toni Smith



Data Sources: Case Study

Source	Nature of Data
Instructional logs	Instructional practices implemented throughout a week of instruction
Classroom videos	Instructional practices implemented in lessons where a new mathematics concept is introduced
Teacher interview	Perceptions of teaching context, philosophy mathematics teaching and learning, instructional practices, and challenges
Student focus groups	Perceptions of their experiences in math class and factors contributing to success in math

Approaches to Math Instruction



- Analysis of video and log data focused on two common parts of math lessons:
 - **Development of new mathematics** - Students are first presented with and time is spent fully developing a new mathematics concept, relationship, rule or procedure.
 - **Reinforcement of mathematics learning** - Students have the opportunity to strengthen their understanding of and skill with mathematics content

Development of New Mathematics



- We observed differences in the frequency and ways in which students contribute to the development of the new mathematical ideas
 - Teacher-guided with some student contribution
 - Teacher-guided with strong student contribution
 - Active student exploration



Examples

- **Teacher-guided with some student contribution**
 - Teacher guides the development by focusing on the conceptual underpinnings, making connections to students lives, and posing low-level questions
- **Teacher-guided with strong student contribution**
 - Teacher guides the development by presenting student with a series of mini-explorations and provides opportunities for students to share their thinking
- **Exploration, with strong student contribution**
 - Teacher engages students in a carefully designed exploration where students work together to reason about and develop the new mathematical ideas



Reinforcement of Mathematics

- Observed differences in
 - Mathematics **problems** offered to students
 - Mathematical **communication** around those problems



Problem: Rote Application

Solve by substitution:

$$y = -x + 2$$

$$y = -\frac{1}{2}x + 1$$

Problem: Reasoning, Critical Thinking and Communication



Faced with the system of equations shown here, two students, Lincoln and Claire, both decided to use the substitution method to find the solution(s).

There are errors in the work of both Lincoln and Claire, but one of them was “lucky” and got the correct solution.

- What are the errors in each case?
- Which student got the correct solution? How do you know?

$$\begin{cases} 5x - y = -15 \\ x + y = -3 \end{cases}$$

Lincoln's Method

$$x = -3 - y \quad \text{So,}$$

$$5(-3 - y) - y = -15$$

$$-15 - y - y = -15$$

$$-15 - 2y = -15$$

$$-2y = 0$$

$$y = 0$$

$$\text{So, } x + (0) = -3$$

$$x = -3$$

The solution is $(-3, 0)$

Claire's Method

$$y = -3 - x \quad \text{So,}$$

$$5x - (-3 - x) = -15$$

$$5x + 3 - x = -15$$

$$4x + 3 = -15$$

$$4x = -18$$

$$x = -4.5$$

$$\text{So, } (-4.5) + y = -3$$

$$y = 1.5$$

The solution is $(-4.5, 1.5)$

Communication: Highly Scaffolded



Teacher:	What multiplies to 8? 1 times 8 and 2 times 4, right? So, if I go with 2 times 4, which one of those is the square?
Student:	Four.
Teacher:	So that's the one I can square root. When I square root that four, what does it become?
Student:	Two.
Teacher:	Good...and then what's left inside still.

Communication: Allow Students to Reason and Persevere



Teacher:	OK, interesting! Interesting! Joan, did you add your variables?
Student:	I don't know what to put for x.
Teacher:	Well, apparently there is not agreement. What you think is best, and we'll have a discussion about that. So, I'm seeing a lot that look alike, but Jonas and Mike, yours looks different. What do you guys want to say about that?
Student:	(We put the) hip angle on the x-axis and the height on the y.
Teacher:	What was your reasoning behind that?
Student:	The height doesn't depend on the hip angle. The hip angle depends on the height.

Summary: Student-Centered Instructional Approaches



Characteristics of Activities/Tasks

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/results

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

Summary: Student-Centered Instructional Approaches



Orchestration of Mathematical Communication

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 in 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

Philosophy, Context & Instruction



- Analysis of the interviews found that case study teachers who implemented more student-centered approaches to math instruction
 - Believe in the importance of these approaches for supporting success in mathematics
 - Work in schools that prepare students for a variety of life pathways
 - Have flexibility in lesson design
 - Have access to instructional resources that emphasize these approaches



Student Perspectives

- Analyses of the focus group data indicated that
 - Students appreciate teachers who
 - Are organized
 - Go out of their way to support student success
 - Help them to develop confidence in mathematics
 - Students in more student-centered approaches to mathematics instruction
 - Find the content meaningful and interesting
 - Begin to like mathematics

Quantitative Findings

Kirk Walters

Data Sources: Quantitative Study



Source	Nature of Data
Challenging assignments	Examples of most challenging assignment offered to target class over a specified period of time
Teacher survey	Frequency of instructional practices implemented with target class
Student survey	Perceptions of their school and their experiences in the target math class
Math problem-solving test	Publicly released items from PISA, an international assessment given to 15- and 16-year-old students



Analytic Approach

- Created independent measure of student-centered instruction
 - Composite: teacher survey items + challenging assignments
- Created dependent measures of math problem solving skills and student engagement
 - Math problem solving skills: 9 public-release items from 2009 PISA; reliability = 0.76
 - Student engagement: student survey items



Sample Problem Solving Item

EXCHANGE RATE

Mei-Ling found out that the exchange rate between Singapore dollars (SGD) and South African rand (ZAR) was $1 \text{ SGD} = 4.2 \text{ ZAR}$. Mei-Ling changed 3,000 Singapore dollars into South African rand at this exchange rate.

HOW MUCH MONEY IN SOUTH AFRICAN RAND DID MEI-LING GET?

On returning to Singapore after three months, Mei-Ling had 3,900 ZAR left. She changed this back to Singapore dollars, noting that the exchange rate had changed to $1 \text{ SGD} = 4.0 \text{ ZAR}$. How much money in Singapore dollars did Mei-Ling get?

During these three months, the exchange rate had changed from 4.2 to 4.0 ZAR per SGD. Was it in Mei-Ling's favor that the exchange rate now was 4.0 ZAR instead of 4.2 ZAR, when she changed her South African rand back to Singapore dollars? Give an explanation to support your answer.



Results

- Students in more student-centered math classrooms reported **higher levels of engagement**, compared to students in less student-centered math classrooms
- Engagement included two sub-constructs:
 - 1) Students' self-assessment of learning
(e.g., “this math class really makes me think”)
 - 2) Students' interest/motivation
(e.g., “in this math class, sometimes I get so interested in my work I don't want to stop”)



Results

- Students in all study classrooms performed well above the U.S. average on each item in study's problem solving assessment
- Students in more student-centered math classrooms showed **higher growth in problem-solving skills**, compared to students in less student-centered classrooms
 - Statistically significant difference in a value-added model
 - Study not designed to measure magnitude of difference

Practitioner Reactions

Joanna Burt-Kinderman, Pocahontas County
Schools (WV)

The core challenge



- We must shift the paradigm of teaching and learning math, and so transform a teaching culture.

A student-centered focus is key



- Learner-centered instruction maximizes problem-solving growth.
- Students must explore, reason and communicate.

Effective coaching mirrors effective teaching



- Teachers are learners with parallel needs:
 - Safe space, respectful community in which to explore
 - Support and input
 - Challenging problems posed

Doing math is messy



- We need:
 - Safe space to be wrong
 - To work through struggle
 - A community in which to collaborate

This research speaks



- As invitation
 - Into increasing key learning opportunities
 - Attend to why, communicate, connect, reason
- As affirmation
 - Of work that is often hard to package simply
- As challenge
 - Towards the complex work of increasing learner-centered instruction

Discussion

Kerstin Le Floch

Your questions





Next Steps

- Study shows promise of student-centered approaches in math and directions for future research
- Future work should involve active, collaborative partnerships between practitioners and researchers
- Nellie Mae and AIR both committed to this work
- Let's keep working to improve what is known about this important topic!

Thank you!

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