Access and Equity in Mathematics Education

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Agenda

- Access and Equity
- Historical Perspective
- Productive and Unproductive Beliefs
- Effective Teaching Practices and Equitable Pedagogy
- Questions

National Council of Teachers of Mathematics Position Statement, 2014

Creating, supporting, and sustaining a culture of access and equity require being responsive to students' backgrounds, experiences, cultural perspectives, traditions, and knowledge when designing and implementing a mathematics program and assessing its effectiveness.

National Council of Teachers of Mathematics Position Statement, 2014

Acknowledging and addressing factors that contribute to differential outcomes among groups of students are critical to ensuring that all students routinely have opportunities to experience high-quality mathematics instruction, learn challenging mathematics content, and receive the support necessary to be successful.

National Council of Teachers of Mathematics Position Statement, 2014

Addressing equity and access includes both ensuring that all students attain mathematics proficiency and increasing the numbers of students from all racial, ethnic, linguistic, gender, and socioeconomic groups who attain the highest levels of mathematics achievement.

2022 NAEP Results

- Largest score declines in NAEP mathematics at grades 4 and 8 since initial assessments in 1990
- 4th grade - Gaps between groups increase
  - Males 6 points higher than females compared to 3 points in 2019
  - White students 29 higher than Black peers compared to 25 points in 2019
  - White students 21 points higher than Hispanic peers compared to 18 points in 2019

2022 NAEP Results

- 8th grade - Some gaps widen
  - Males 2 points higher than females compared to no difference in 2019
  - Gaps between White and Black students, and White and Hispanic students do not change
  - White students consistently score about 32 points higher than Black students and around 24 points higher than Hispanic students

Achieving Access and Equity Requires that all Stakeholders:

- Ensure that all students have access to a challenging mathematics curriculum, taught by skilled and effective teachers who differentiate instruction as needed.
- Monitor student progress and make needed accommodations.
- Offer remediation or additional challenges when appropriate.

(NCTM, 2014)

Historical Perspective

- Consistent questions:
  - Who should learn mathematics?
  - What mathematics should be taught?
- Historically mathematics has been viewed as a gatekeeper.
- Access to quality mathematics education has often been limited as a result.

Historical Perspective - 1600s and 1700s

- Colonial times - education focused mainly on literacy and the classics for the elite
- Some arithmetic taught - primarily for business
- Franklin’s crusade for utilitarian education increased teaching of arithmetic
- Eventually, proficiency in arithmetic became requirement for college entrance.

(Furr, 1996)

Historical Perspective - Warren Colburn

- 1821 - First edition of *First Lessons in Arithmetic*
- Designed to lead children through discovery of concepts of numbers and operations - opposite of rule method
- Began with practical problems using early manipulatives
- Understanding of operation comes first followed by use of numbers and operation signs
- Sales of books were high but method not always implemented

(Furr, 1996)

Historical Perspective - Common School Movement

- 1830 - 1872
- Increased number of students learning arithmetic
- Few privileged males learned algebra and geometry
- Shortage of trained teachers led to reliance on rule method in which students are presented a rule for a specific problem, and then memorized and drilled on the rule.
- Females were not taught rules and practical knowledge came from life experience.

(Furr, 1996)

Historical Perspective - Late 19th and Early 20th Century

- Remainder of 1800s - mathematics viewed as tool for practicing reasoning
- Teaching characterized by drill and discipline
- Push to focus only on the mathematics needed in daily life
- Need for mathematics to be studied was debated
- William Kilpatrick – Too many, not too few, have been taught algebra and geometry

(Klein, 2005)

Historical Perspective - 1930s

- School curriculum is determined by the needs and interests of children.
- Curriculum is integrated in elementary grades and math is not a separate subject.

(Klein, 2005)

Historical Perspective - 1940s

- Army recruits knew very little math and military had to provide training
- 60% or more of high school students assumed to lack intellectual capability for college or skilled occupations
- This 60% needed a school program to prepare them for daily life and as unskilled or semi skilled laborers

(Klein, 2005)

Historical Perspective - 1950s and 1960s

- Early 1950s - New Math - collision between skill instruction and understanding
- New math curricula emphasized logical explanations for mathematical procedures
- 1957 - launch of Sputnik - press called attention to low quality of math and science education in schools
- More math taught in schools - introduction of calculus at the high school level

(Klein, 2005)

Historical Perspective - 1970s

- New Math is gone.
- Back the basics movement begins
- Allowing children to determine what and when they learn is revived
- This was detrimental to children with limited resources due to a lack of access to supplemental education at home and tutoring if needed.
- Low income and minority children most dramatically impacted.

(Klein, 2005)

Historical Perspective - 1980s

- Widespread recognition that the quality of mathematics education was decreasing.
- Low enrollments in advanced classes.
- Calls for increased problem solving
- Introduction of calculator use

(Klein, 2005)

Historical Perspective - A Nation at Risk

- 1983 report
- Remedial math course have increased in public colleges and ¼ of all mathematics courses are remedial in nature
- Business and military leaders spend money and time on remedial education
- Teacher education criticized

(Klein, 2005)

Historical Perspective - Robert Moses

- Access to mathematics is a civil right.
- “I believe that the absence of math literacy in urban and rural communities throughout this country is an issue.”
- “Economic access and full citizenship depend crucially on math and science literacy.”
- Founded Algebra Project in 1982

(Curry, 2018)

Historical Perspective - Late 20th Century

- Standards movement begins
- Understanding procedures is emphasized
- Reduced emphasis on memorization
- Discovery and cooperative learning are encouraged
- NSF funds several curriculum projects

(Klein, 2005)

Importance of the Teacher

- Student learning of mathematics depends on what happens inside the classroom (Ball & Forzani, 2011)
- Students living in poverty (rural or urban) tend to have teachers who are not well-prepared and have less teaching experience. (NCTM, 2014)
- Beliefs of educators are key.

Productive or Unproductive Belief?

slido

Equity means that all students need to receive the same learning opportunities so that they can achieve the same academic outcomes.

slido

Students possess different innate levels of ability in mathematics, and these cannot be changed by instruction. Certain groups of individuals have it while others do not.

slido

Mathematics learning is independent of students' culture, conditions, and language, and teachers do not need to consider any of these factors to be effective.

Effective Mathematics Teaching Practices, NCTM 2014

- Establish mathematics goals to focus learning
- Implement tasks that promote reasoning and problem solving
- Build procedural fluency from conceptual understanding
- Pose purposeful questions
- Use and connect mathematical representations
- Facilitate meaningful mathematical discourse
- Elicit and use evidence of student thinking
- Support productive struggle in learning mathematics

Equity-Based Instructional Practices

- Go deep with the mathematics - Develop students' conceptual understanding, procedural fluency, and problem solving and reasoning
- Leverage multiple mathematical competencies - Use students' different mathematical strengths as a source for learning

(Aguirre et al. 2013)

Equity-Based Instructional Practices

- Affirm mathematics learners' identities - Promote student participation and value different ways of contributing
- Challenge spaces of marginality - Embrace student competencies, value multiple mathematical contributions, and position students as sources of expertise
- Draw on multiple resources of knowledge (mathematics, language, culture, family) Tap students' knowledge and experiences as resources for mathematics learning

(Aguirre et al. 2013)

Establish Mathematical Goals to Focus Learning

Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.

NCTM, 2014

How are these goals alike and different?

- Goal 1: Students will solve a variety of multiplication word problems and write the related multiplication equations.
- Goal 2: Students will understand the structure of multiplication as comparing equal groups within visual or physical representations, understand the numbers in multiplication equations, and connect representations to multiplication equations.

(Huinker & Bill, 2017)

Establish Mathematical Goals to Focus Learning - Promoting Equity

- Learning goals emphasize the belief that ALL students should be provided with opportunities to learn mathematics, build understanding, solve problems, and develop conceptual understanding.
- Learning goals situated within learning progressions support teachers meeting the students where they are.

Establish Mathematical Goals to Focus Learning - Promoting Equity

- Goals chosen by the teacher influence the development of productive dispositions towards mathematics and too much reliance on performance goals can be detrimental.
- Goals frame the tasks the teacher chooses and students' opportunities to learn.
- Situational contexts support students by helping them connect mathematics to their everyday lives.

(Smith, Steele, & Raith, 2017)

Implement Tasks that Promote Reasoning and Problem Solving

Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.

NCTM, 2014

Comparing Tasks

Multiples of Ten Task	Band Concert Task
Solve the following multiplication problems: 7 x 10 = 7 x 20 = 5 x 50 = 40 x 7 = 10 x 9 = 5 x 20 =	The third-grade class is responsible for setting up the chairs for the spring band concert. In preparation, the class needs to determine the total number of chairs that will be needed. The class needs to set up 7 rows of chairs with 20 chairs per row, leaving space for a center aisle. How many chairs will be needed?

How might students solve this?

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Implement Tasks that Promote Reasoning and Problem Solving - Promoting Equity

- High-level tasks promote high mathematical expectations for students.
- High-level tasks allow multiple entry points and multiple solution strategies.
- Tasks must be launched in a way that all students understand what is expected of them and providing them with appropriate resources (one of equity-based practices).

Implement Tasks that Promote Reasoning and Problem Solving - Promoting Equity

- Engaging students in high-level tasks allow students to deeply explore mathematics (equity based practice).
- High-level tasks are often appropriate for collaborative work in groups. This creates opportunities for students to see how each group member is “smart” (Fernandes, Crespo, & Civil, 2017).

Build Procedural Fluency from Conceptual Understanding

Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibility as they solve conceptual and mathematical problems.

(NCTM, 2014)

Fluency

- In the past, fluency has often been described in terms of speed.
- Being fluent means that students are able to choose flexibly among methods and strategies to solve contextual and mathematical problems, they understand and are able to explain their approaches, and they are able to produce accurate answers efficiently (NCTM, 2014).

Build Procedural Fluency from Conceptual Understanding - Promoting Equity

- Equitable mathematics teaching emphasizes going deep with mathematics (Aguirre, Mayfield-Ingram, & Martin, 2013)
  - This includes a deep understanding of procedures and rules that allow use and application of the procedures.
  - A focus on memorization of procedures as steps to follow limits use of the procedure.

Build Procedural Fluency from Conceptual Understanding - Promoting Equity

- Students considered to be struggling learners in mathematics may have conceptual gaps that cause them to fall further behind.
- Well-intended intervention programs that focus only on memorizing and practicing skills may increase the gaps.

Pose Purposeful Questions

Effective teaching of mathematics uses purposeful questions to assess and advance student reasoning and sense making about important mathematical ideas and relationships.

(NCTM, 2014)

Pose Purposeful Questions - Question Stems

- That seems really important, who can say that again?
- Who can say that back in your own words?
- What does she mean when she says …?
- Who can add on to that explanation?
- Do you agree or disagree with …? Why?
- Turn and talk with a partner about … Who can tell the class what your partner said?
- Who has a similar way of looking at that? Who has a different way?
- Let's look at these two approaches. How are they similar? How are the different?

(Huinker & Bill, 2017)

Pose Purposeful Questions - Response Stems

- I agree with … because…
- I respectfully disagree with that because…
- I still have questions about …
- I'm confused by …
- I have a different perspective because…
- I connected with what … said because…
- I chose this method because …
- May I add on to what … said about …?
- I was wondering…
- May we try that strategy on a new problem?

(Huinker & Bill, 2017)

Pose Purposeful Questions

Assessing Questions	Advancing Questions
● Based closely on the student's current work and strategy. ● Clarify aspects of the student work and strategy and determine what the student understands. ● Provide information to the teacher about what the students understands. ● Teacher stays to hear the answer.	● Use student work as the basis for making towards to the target goal or to move along a learning trajectory. ● Move students beyond their current thinking. ● Prompt students to think about a mathematical ideas they are not currently considering. ● Teacher leaves students to figure out how to proceed.

Pose Purposeful Questions - Promoting Equity

- Intentional teacher questioning ensures all students progress and develop a strong mathematical identity.
- Teacher questioning impacts how students view themselves as mathematics learners.
- Who is called on? Whose thinking is shared?

Use and Connect Mathematical Representations

Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.

(NCTM, 2014)

Use and Connect Mathematical Representations

- Visual
- Symbolic
- Physical
- Contextual
- Verbal

Visual, Symbolic, Physical, Contextual, Verbal

Represent this problem using at least 2 of the types of representations listed above.

Find the product of 4 and 7.

Use and Connect Mathematical Representations - Promoting Equity

- Giving students choice in selecting representations and allowing time for students to explore, construct, and discuss representations supports equity as students deepen their mathematical knowledge.
- Focus on choice in representations supports that mathematics learning is not one size fits all.
- Use of multiple representations allows students to draw on multiple resources of knowledge and to pose their own contexts.

Facilitate Meaningful Mathematical Discourse

Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing students approaches and arguments.

(NCTM, 2014)

Facilitate Meaningful Mathematical Discourse

- What is the teacher's role?
- Who asks the questions?
- Who provides the explanations?
- How do mathematical representations support discourse?
- How are students sharing responsibility for learning?

(Hufferd-Ackles, Fuson, and Sherin, 2015)

Discourse - What is the Teacher's Role?

- Level 0 - Teacher is at the front of the room and dominates conversation.
- Level 1 - Teacher encourages sharing of math ideas and directs speaker to talk to the class, not to the teacher only.
- Level 2 - Teacher facilitates conversation between students, and encourages students to ask questions of one another.
- Level 3 - Students carry on conversations themselves. Teacher guides from the periphery of the conversation. Teachers waits for students to clarify the thinking of others.

(Hufferd-Ackles, Fuson, and Sherin, 2015)

Facilitate Meaningful Mathematical Discourse - Promoting Equity

- Discourse-based classrooms provide stronger access to mathematics for all - those who have immediate ideas, those who need more time, those with reasoned approaches, those with misconceptions.
- Meaningful discourse can challenge the spaces of marginality (Aguirre, Mayfield-Ingram, and Martin 2013) by including more student voices and valuing contributions of all.

Facilitate Meaningful Mathematical Discourse - Promoting Equity

- Discourse-based classrooms allow for mathematical authority to be shared and interconnected.
- Interactions help students see themselves as those who know, do and make sense of mathematics.

Elicit and Use Evidence of Student Thinking

Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

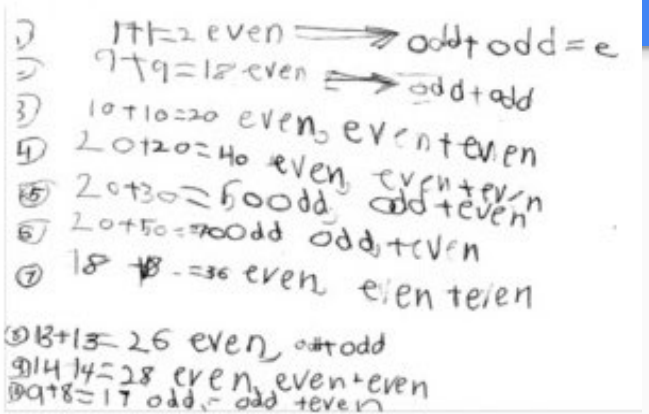
(NCTM, 2014)

Elicit and Use Evidence of Student Thinking - Odd and Even Task

- Is the sum of two even numbers, even or odd, and how do you know?
- Is the sum of two odd numbers, even or odd, and how do you know?
- Is the sum of an odd number and an even number, even or odd, and how do you know?

What does Seth's work tell you about his understanding?

Seth's examples of adding odd and even numbers using his choice of number



Is the sum of two even numbers, even or odd? How do you know?

I also discoverd that even+even because, 20+20=40 and 40 is an even number because it end in a 0.

Is the sum of two odd numbers, even or odd? How do you know?

I know that odd+odd = even because 9+9=18 and 18 is an even number because it ends in a 8.

Is the sum of an even and an odd number, even or odd? How do you know?

I know even+odd=odd because 20+15=35

35 is odd because it doesn't have a partner. 20+15=35 20 has a partner but 15 has one left over so you put it with 20 and it still has one left over.

Elicit and Use Evidence of Student Thinking - Promoting Equity

- Whose work is selected and discussed sends a powerful message and this shapes students' identities.
- Promoting a message that mistakes are viewed as opportunities encourages broader participation.
- Allows teachers to see the ways in which students are drawing on multiple sources of knowledge.

(NCTM, 2014)

Support Productive Struggle in Learning Mathematics

Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and support to engage in productive struggle as they grapple with mathematical ideas and relationships.

(NCTM, 2014)

Teacher Responses to Struggle - A Continuum

- Telling
- Directed Guidance
- Probing Guidance
- Affordance

(Warshauer, 2015)

Support Productive Struggle in Learning Mathematics - Teaching Strategies

- Ask questions
- Provide encouragement
- Give adequate time
- Acknowledge student contributions

(Warshauer, 2015)

Support Productive Struggle in Learning Mathematics - Promoting Equity

- Idea that mistakes are ok influences how students see themselves as learner of mathematics.
- Equity is promoted when identity is not tied solely to quick and correct answers.
- Change needed - view mathematics as a subject of learning and not of performance.

(NCTM, 2014)

Four Pillars of Practice for Development of Identity

- Knowing and believing in your students
- Redefining mathematical success
- Prioritizing student voice
- Monitoring identity formation

(Allen and Schnell, 2016)

Access and equity in mathematics at the school and classroom levels rest on beliefs and practices that empower all students to participate meaningfully in learning mathematics and to achieve outcomes in mathematics that are not predicted by or correlated with student characteristics.

(NCTM, 2014)

Thank you!

Aguirre, J. K. & Martin, D. B. (2013). *The impact of identity in K-8 mathematics.* NCTM.

Allen, K. & Schnell, K. (2016). Developing mathematics identity. *Mathematics Teaching in the Middle School, 21*(7), 398-405.

Ball, D. L. & Forzani, F. M. (2010). Teaching skillful teaching. *Educational Leadership, 68*(4), 40-45.

Curry, D. (2018). Math is a civil right: The story of Bob Moses and the algebra project. Available: https://changeagent.nelrc.org/wp-content/uploads/2018/08/37-Math-Is-a-Civil-Right.pdf

Fernandes, A., Crespo, S., & Civil, M. (2017). Access and equity: Promoting high-quality mathematics. NCTM.

Hufferd-Ackles, K., Fuson, K. C., Sherin, M. G. (2015). Describing levels and components of a math-talk learning community. In E. E. Silver and P.A. Kenney (Eds.), *More lessons learned from research: Useful and usable research related to core mathematical practices volume 1* (pp. 125-134). NCTM.

Furr, J. (1996). A brief history of mathematics education in America. Available:: http://jwilson.coe.uga.edu/EMAT7050/HistoryWeggener.html

Huinker, D. & Bill, V. (2017). Taking action: Implementing effective mathematics teaching practices in K-5. NCTM.

Klein, D. (2005). A brief history of American K-12 mathematics education in the 20th century. In Royer, J.M. (Ed.), *Mathematical cognition.* Information Age Publishing.

National Council of Teachers of Mathematics. (2014). Access and equity in mathematics education: A position of the National Council of Teachers of Mathematics. Available: https://www.nctm.org/uploadedFiles/Standards_and_Positions/Position_Statements/Access_and_Equity.pdf

National Council of Teachers of Mathematics. (2014). *Principles to action: Ensuring mathematical success for all.* NCTM.

Smith, M.S., Steele, M. D. & Raith, M.L. (2017). Taking action: Implementing effective mathematics teaching practices in 6-8. NCTM.

Warshauer, H. K. (2015). Strategies to support productive struggle. *Mathematics Teaching in the Middle School, 20*(7), 390-393.