(How) Could U.S. K-12 Mathematics Education Actually Be Improved? Breaking the Cycle of Yo-Yo Reforms

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Simons Laufer Mathematical Sciences Institute

Committee of Academic Sponsors & Trustees Dinner

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UNIVERSITY OF MICHIGAN SCHOOL OF EDUCATION | TEACHINGWORKS

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The argument of tonight's talk

1. The premise: K-12 mathematics education is not working for most U.S. young people and this matters.
2. Reforms are, in part, rooted in persistent myths and not in knowledge of what real improvement would take.
3. Improving young people's mathematics learning will depend on valid knowledge about practice and intervention.
4. Math departments have a special responsibility in this endeavor.

repairing longstanding patterns of racial inequity

building the STEM workforce

What are we after?

improving mathematics achievement by U.S. students

growing a generation of adults who don't disidentify with math

broadening our conceptions of mathematics and mathematical competence

But we have been here before.

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many times

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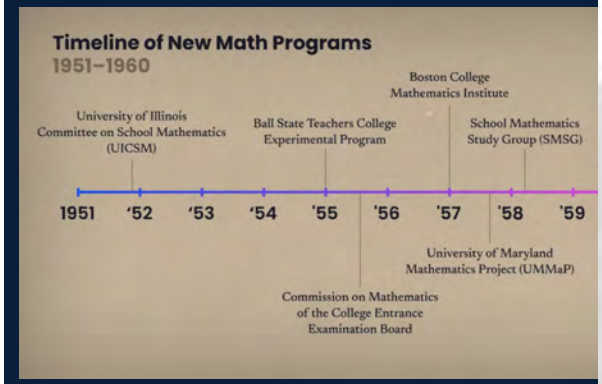
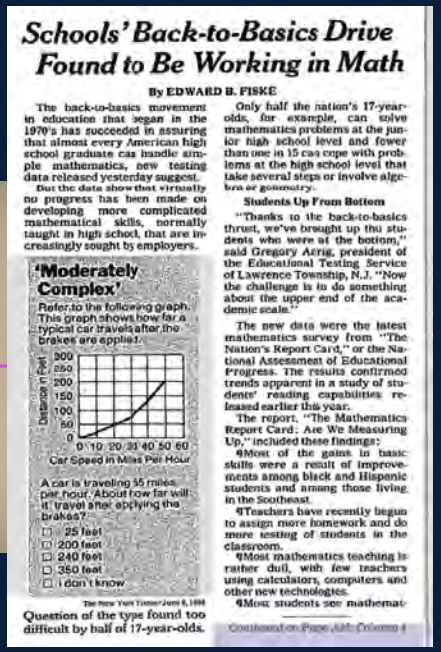


1950–60s


Schools' Back-to-Basics Drive Found to Be Working in Math

By EDWARD B. FISKE

The back-to-basics movement in education that began in the 1970's has succeeded in assuring that almost every American high school graduate can handle simple mathematics, new testing data released yesterday suggest.

But the data show that virtually no progress has been made on developing more complicated mathematical skills, normally taught in high school, that are increasingly sought by employers.

Only half the nation's 17-year-olds, for example, can solve mathematics problems at the junior high school level and fewer than one in 15 can cope with problems at the high school level that take several steps or involve algebra or geometry.

Students Up From Bottom

"Thanks to the back-to-basics thrust, we've brought up the students who were at the bottom," said Gregory Anrig, president of the Educational Testing Service of Lawrence Township, N.J. "Now the challenge is to do something about the upper end of the academic scale."

The new data were the latest mathematics survey from "The Nation's Report Card," or the National Assessment of Educational Progress. The results confirmed trends apparent in a study of students' reading capabilities released earlier this year.

The report, "The Mathematics Report Card: Are We Measuring Up," included these findings:

¶Most of the gains in basic skills were a result of improvements among black and Hispanic students and among those living in the Southeast.

¶Teachers have recently begun to assign more homework and do more testing of students in the classroom.

¶Most mathematics teaching is rather dull, with few teachers using calculators, computers and other new technologies.

¶Most students see mathemat-

Continued on Page A20, Column 4

'Moderately Complex'

Refer to the following graph. This graph shows how far a typical car travels after the brakes are applied.

Distance in Feet: 300, 250, 200, 150, 100, 50, 0

0 10 20 30 40 50 60

Car Speed in Miles Per Hour

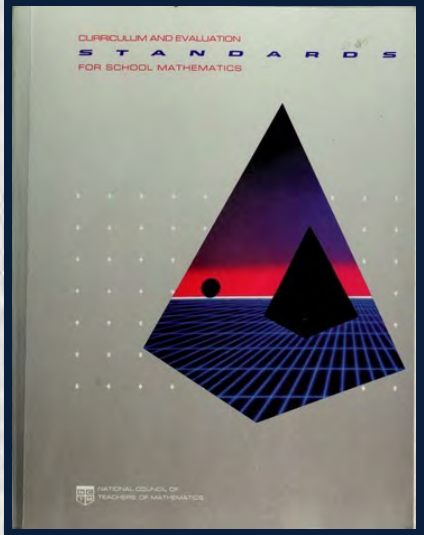
A car is traveling 35 miles per hour. About how far will it travel after applying the brakes?

- 25 feet
- 200 feet
- 240 feet
- 350 feet
- I don't know

The New York Times, June 8, 1986

Question of the type found too difficult by half of 17-year-olds.

1970–1985



1990s

2010–

What have been the patterns?

repeated investments in designing and implementing new curriculum materials

What else have been the patterns?

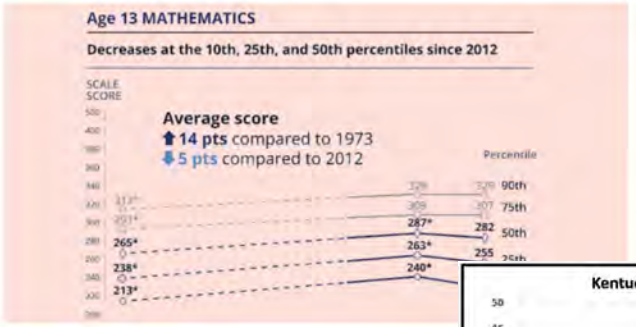
recurrent worries about achievement data

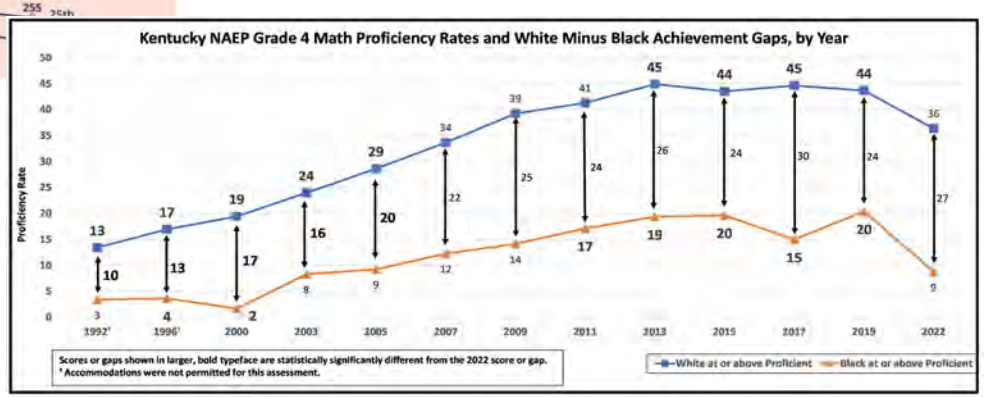
U.S. STUDY SHOWS PUPIL ACHIEVEMENT AT LEVEL OF 1970

American elementary and secondary school pupils have made some educational progress in recent years, but they are only now reaching the achievement levels of students in 1970, according to a major Federal report issued today, which added that students are unprepared for the complex and demanding world of the 21st century. "Today's children seem to know about as much math and about as much science and read about as well as their parents did at that age about 20 years ago," Education Secretary Lamar Alexander said of the report, "Trends in Academic Progress."

October 1, 1991

Long-Term NAEP Scores for 13-Year-Olds Drop for First Time Since Testing Began in 1970s — 'A Matter for National Concern,' Experts Say





And another pattern . . .

A systematic lack of understanding of the work of teaching and its centrality to learning

and instead working *around* teachers to improve learning

Meanwhile, arguments and polarized discourse persist between the mathematics and education communities

And after seven decades of cycles of ”reform,” there is little significant change.

Many (even most) classrooms look much the same.

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Many (even most) classrooms look much the same.

What would it take to NOT be having this same conversation in 2033?

First, we would have to sort out myths from truths.

Two definitions of "myth":

1. a traditional story or set of stories, especially one concerning the early history of a people or explaining some natural or social phenomenon
2. a commonly believed but false idea

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Myth or truth?

1. In most U.S. classrooms, students explore mathematical concepts and are not expected to carry out procedures or develop fluency in mathematics.
2. We do not recruit the best and the brightest to teaching.
3. Teacher preparation is not intellectually challenging and just focuses on pedagogy and theory.
4. Teachers are not required to take enough mathematics
5. Developing high-quality mathematics curriculum is the way to improve mathematics learning.

Myth or truth?

1. **M** In most classrooms, students explore mathematical concepts and are not expected to carry out procedures or develop fluency in mathematics.
2. **T** We do not recruit the best and the brightest to teaching.
3. **M** Teacher preparation is not intellectually challenging and just focuses on pedagogy and theory.
4. **M** Teachers are not required to take enough mathematics.
5. **M** Developing high-quality mathematics curriculum is the way to improve mathematics learning.

What would it take to break the cycles of “reform” and the polarized discourses?

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Focus on the **work of teaching** mathematics.

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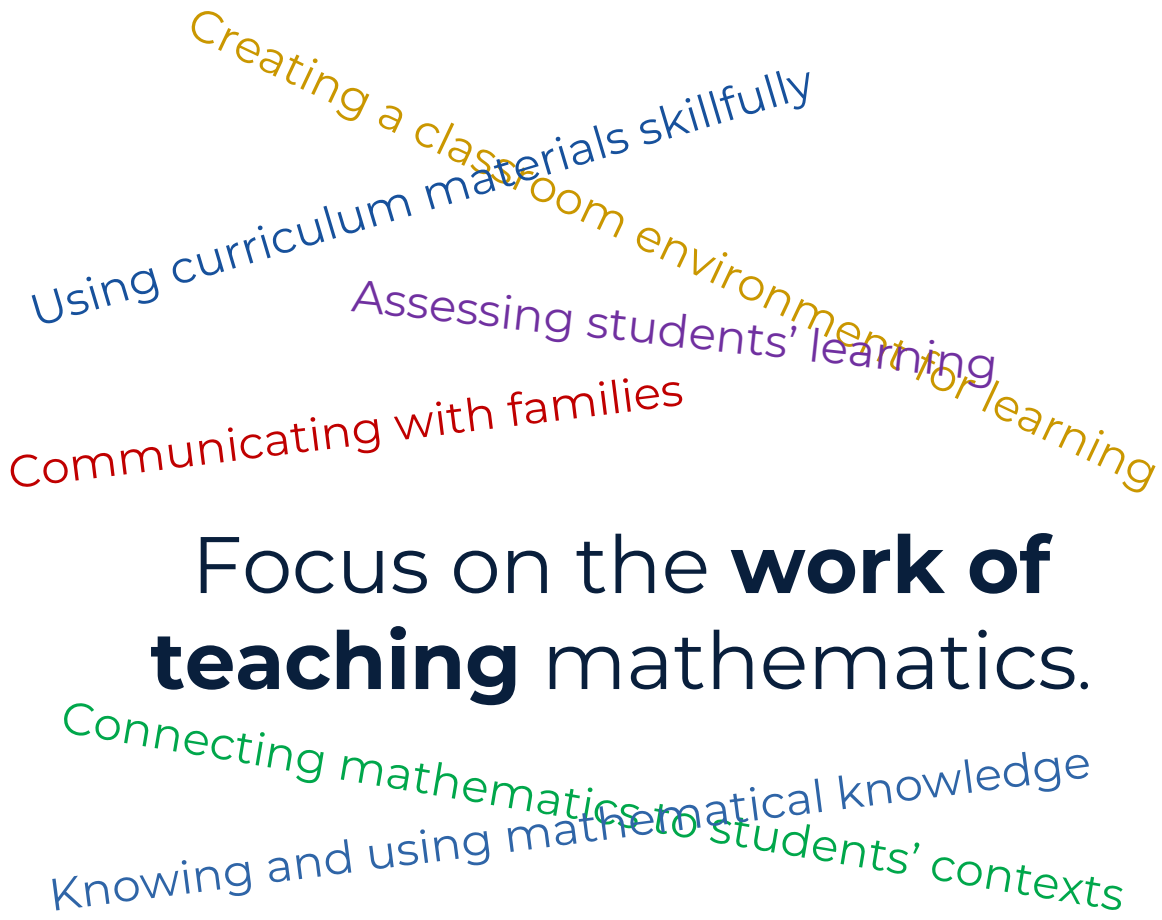


We'll focus on just one of these things about the work of teaching mathematics.

It is something on which we agree:

Teaching mathematics requires knowing the subject matter.

But if we want to improve mathematics learning, we must revise common ideas about what this entails.

1. **Teaching mathematics requires specialized understanding of and fluency with mathematical content.**

$$\begin{array}{r} 49 \\ \times\ 25 \\ \hline \end{array}$$

What mathematical steps produced each of these answers? Why might someone do the problem in this way?

(a)

$$\begin{array}{r} 49 \\ \times\ 25 \\ \hline 405 \\ 108 \\ \hline 1485 \end{array}$$

(b)

$$\begin{array}{r} 49 \\ \times\ 25 \\ \hline 225 \\ 100 \\ \hline 325 \end{array}$$

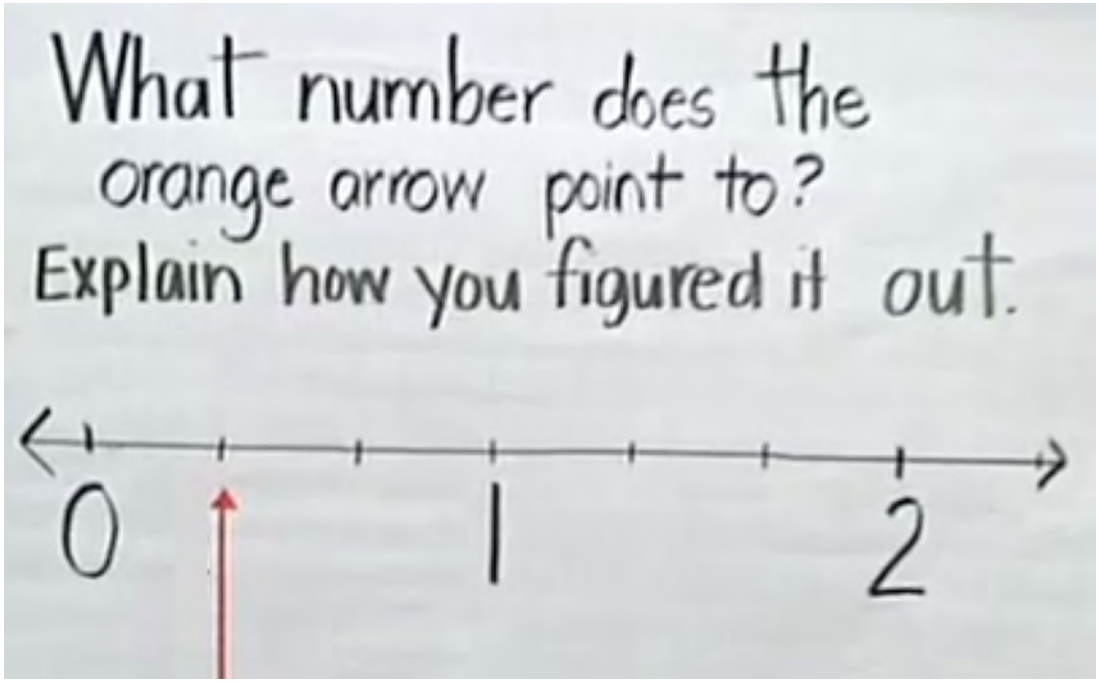
(c)

$$\begin{array}{r} 49 \\ \times\ 25 \\ \hline 1250 \\ 25 \\ \hline 1275 \end{array}$$

2. **Teaching mathematics requires a dynamic application of mathematical knowledge in context, combined with knowledge about students, learning, and equity.**

Fractions as numbers:
The instructional goal for student understanding

3.NF.2.a
Represent a fraction 1/b on a number line diagram by defining the interval from 0 to 1 as the whole and partitioning it into b equal parts. Recognize that each part has size 1/b and that the endpoint of the part based at 0 locates the number 1/b on the number line.



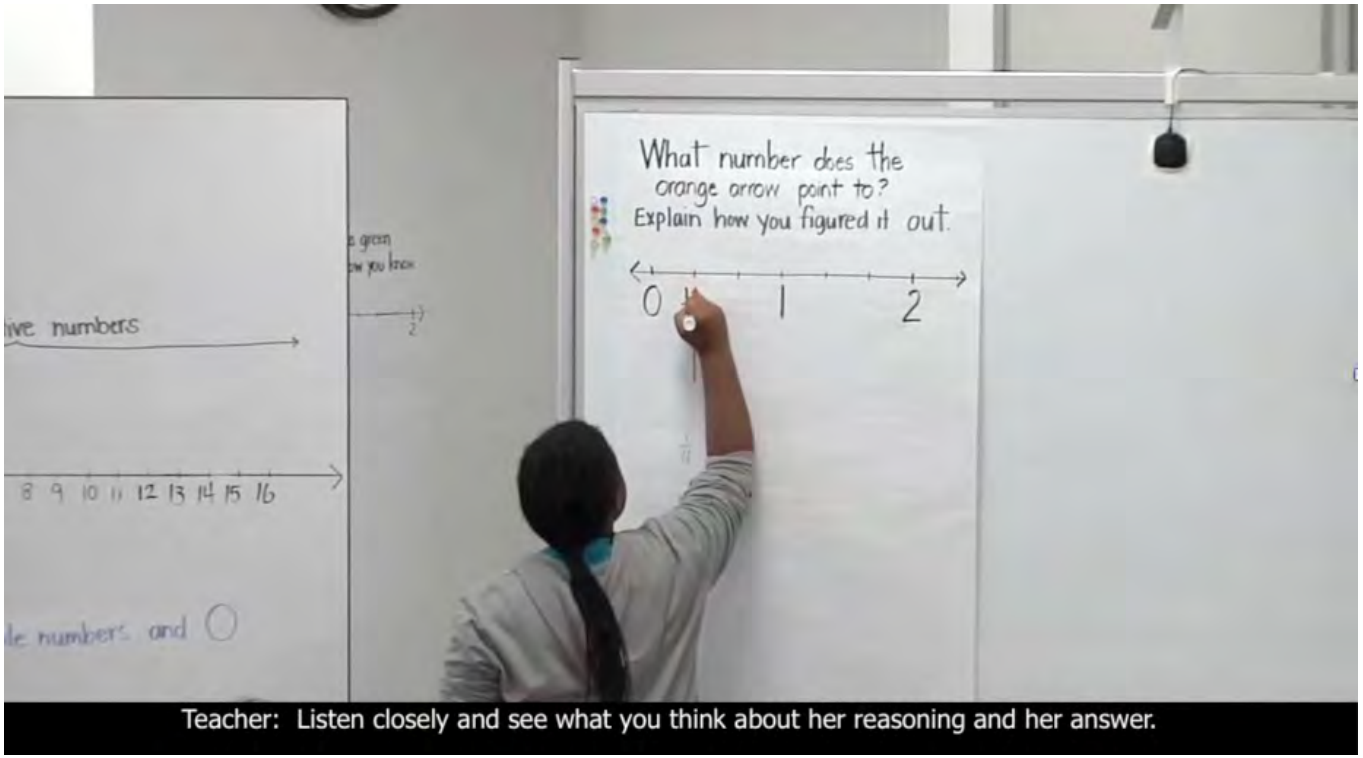
Aniyah

Toni

Viewing focus

What do you see about each girl's mathematical knowledge and skill?

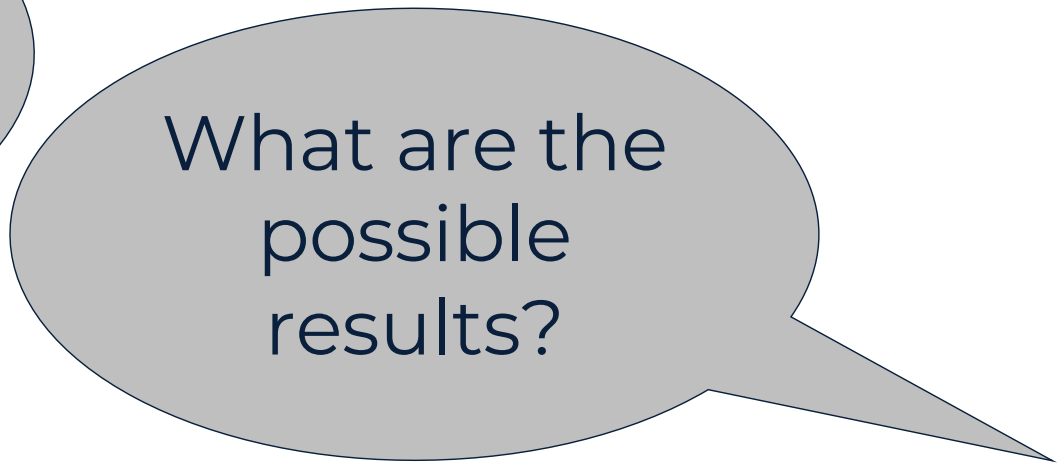
Video: Aniyah and Toni



This video and additional supporting materials are available online here.

Discuss

What do you see about each girl's mathematical knowledge and skill?



In the next moment, what is likely to happen?

NORMALIZED NEXT MOVES

RESULTS

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NORMALIZED NEXT MOVES

- “Can someone help Aniyah out and show what we call the whole on the number line?”

RESULTS

- Aniyah is excluded and her mathematical contributions are sidelined.

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- "Can someone help Aniyah out and show what we call the whole on the number line?"
- "Great, Aniyah, almost! But remember that the whole is from 0 to 1."

RESULTS

- Aniyah is excluded and her mathematical contributions are sidelined.
- Aniyah's answer is signaled to be incorrect and she is positioned as not having contributed to the work.

In the next moment, what is likely to happen?

NORMALIZED NEXT MOVES

- "Can someone help Aniyah out and show what we call the whole on the number line?"
- "Great, Aniyah, almost! But remember that the whole is from 0 to 1."
- "Thumbs up if you agree with Aniyah; thumbs down if you disagree."

RESULTS

- Aniyah is excluded and her mathematical contributions are sidelined.
- Aniyah's answer is signaled to be incorrect and she is positioned as not having contributed to the work.
- Aniyah's solution is "voted" on by her classmates.

What else is likely?

NORMALIZED NEXT MOVES **RESULTS**

What else is likely?

NORMALIZED NEXT MOVES

- "Toni, when you're ready to participate appropriately by not playing with your hair and laughing, and have a question to ask, I will come back to you."

RESULTS

- Toni is publicly excluded from the discussion.

What else is likely?

NORMALIZED NEXT MOVES

- "Toni, when you're ready to participate appropriately by not playing with your hair and laughing, and have a question to ask, I will come back to you."
- "You need to be a better listener, Toni. Aniyah already explained why she picked one-seventh. Who else has a real question for Aniyah?"

RESULTS

- Toni is publicly excluded from the discussion.
- Toni is judged to not be listening, her question is judged as not good, and she is excluded from the discussion.

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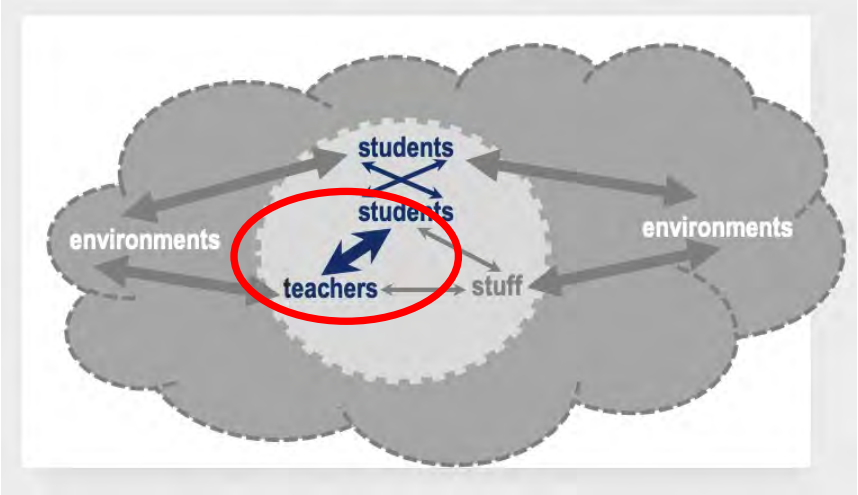
NORMALIZED NEXT MOVES

- "Toni, when you're ready to participate appropriately by not playing with your hair and laughing, and have a question to ask, I will come back to you."
- "You need to be a better listener, Toni. Aniyah already explained why she picked one-seventh. Who else has a real question for Aniyah?"
- "In this classroom, we are respectful of one another. When you are ready to be respectful, you can rejoin the discussion, Toni."

RESULTS

- Toni is publicly excluded from the discussion.
- Toni is judged to not be listening, her question is judged as not good, and she is excluded from the discussion.
- Toni is publicly named and shamed as "disrespectful," rebuked, and her role in advancing the mathematics is sidelined.



Speaker	Talk	Discretionary space
Teacher	Who would like to try to explain what you think the answer is? And show us your reasoning by coming up to the board? Who'd like to come up to the board and try to tell– And you know, it might not be right. That's okay because we're learning something new. I'd like someone to come up and sort of be the teacher and explain how you are thinking about it. Who'd like to try that this morning?	1. Deciding when to open whole-group discussion 2. Deciding what to do to launch discussion 3. Framing the expectation for presenting 4. Framing of what it "coming to the board" entails
Teacher	Okay. Aniyah?	5. Selecting a student to present
Toni Other children	*Playing with hair* *Laying on arms*	6. Deciding whether to comment 7. Deciding whether to comment
Teacher	When someone's presenting at the board, what should you be doing?	8. Setting norms for what to do when a student is presenting
Students in chorus	Looking at them.	
Teacher	Looking at that person–	9. Responding to students
Teacher	Uh-huh?	10. Taking up an individual student question
Aniyah	You want me to write it?	
Teacher	You're trying to mark what you think this number is and explain how you figured it out.	11. Clarifying task
Teacher	Listen closely and see what you think about her reasoning and her answer. *(Aniyah writes ⅐ by the orange line).*	12. Setting task for the other students
Aniyah	I put one-seventh because there's–	
Toni	Did she say one-seventh?	13. Responding to student
Aniyah	*(turns to Toni)* Yeah. *(continues to class)* Because there's seven equal parts, like one, two, three, four, five, six, and then seven. *(Uses her fingers to count the parts on the number line).*	
Teacher	Before you agree or disagree, I want you to ask questions if there's something you don't understand about what she did. No agreeing and disagreeing. Just– All you can do right now is ask Aniyah questions. Who has a question for her?	14. Setting task for responding to student explanation
Teacher	Okay, Toni, what's your question for her?	15. Selecting student to speak
Dante	You did not!	16. Responding to student speaking across room
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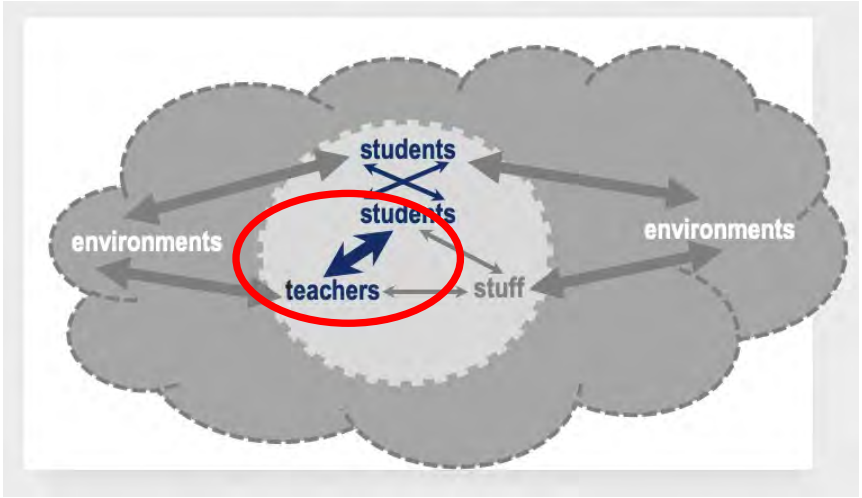

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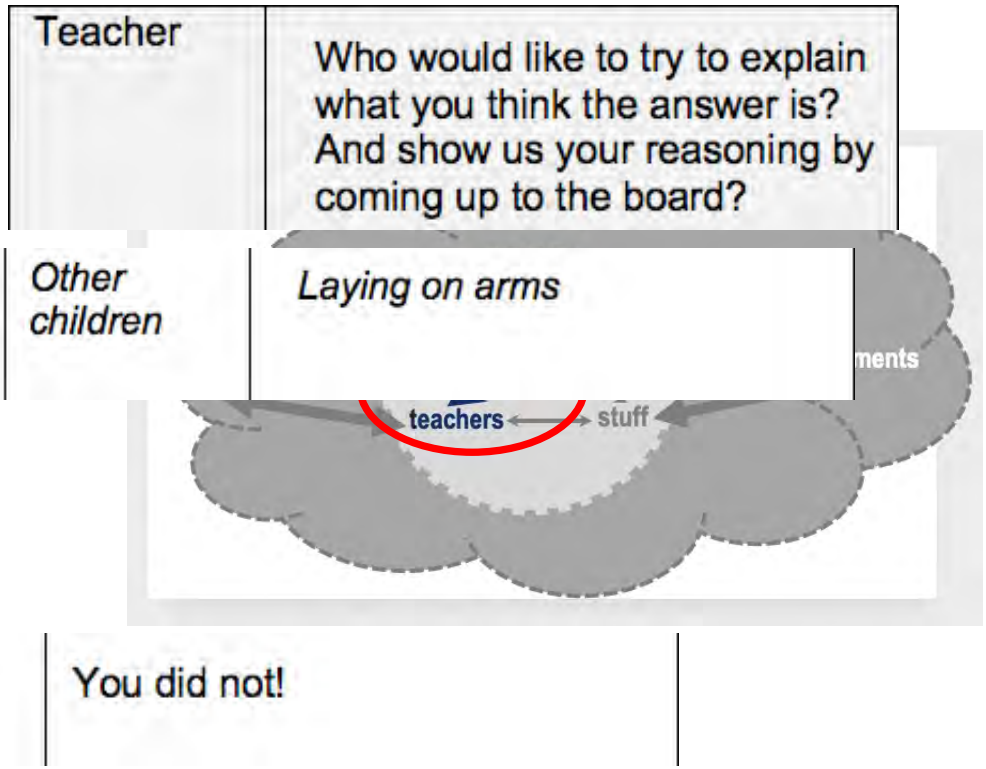

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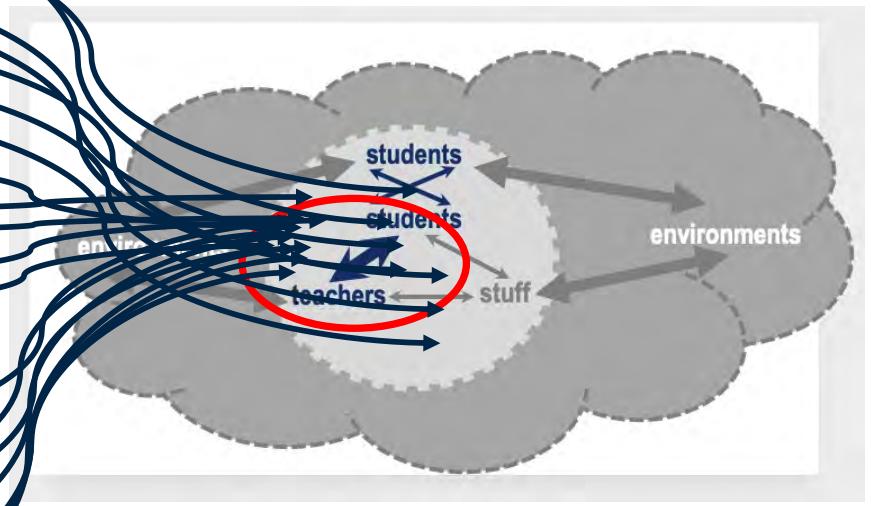

Teaching is dense with “discretionary spaces”

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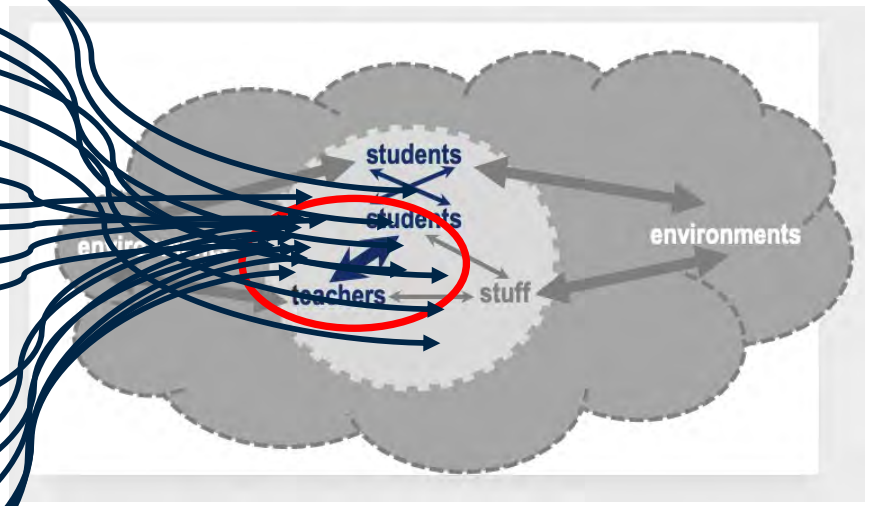
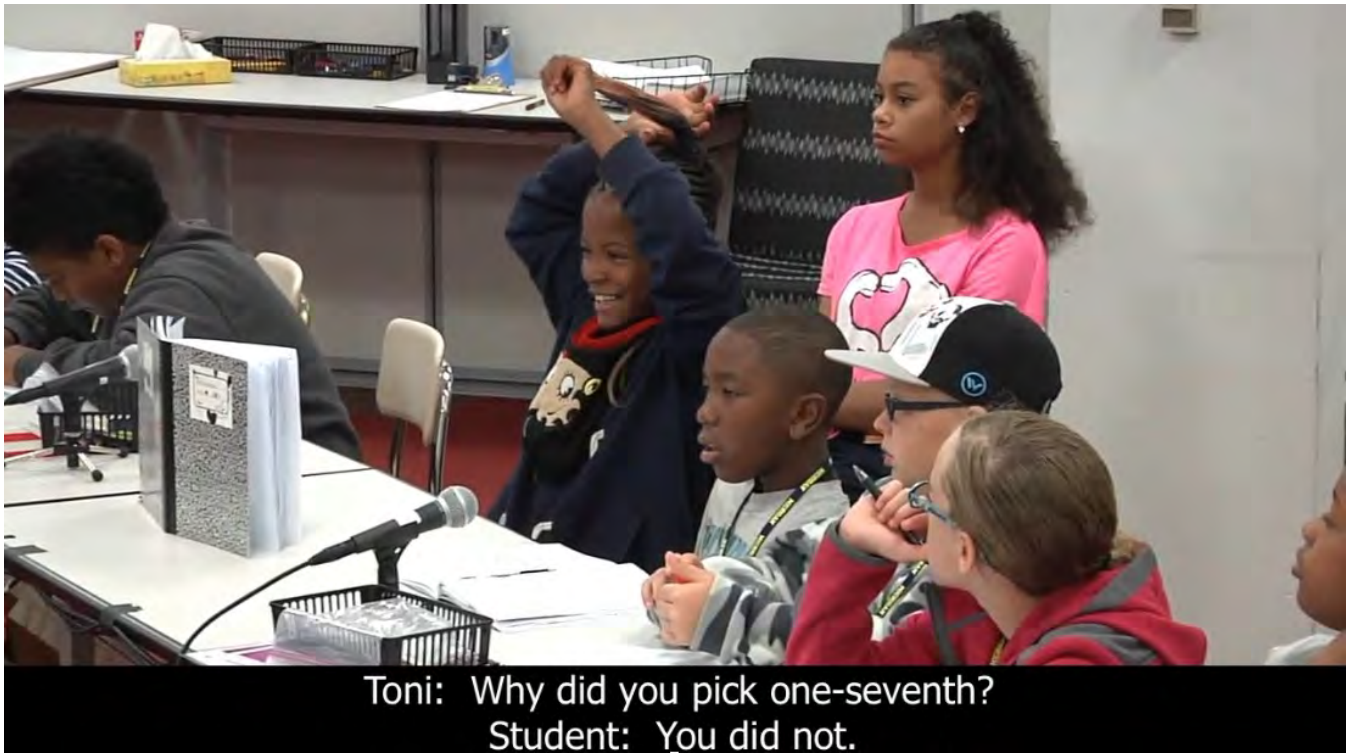


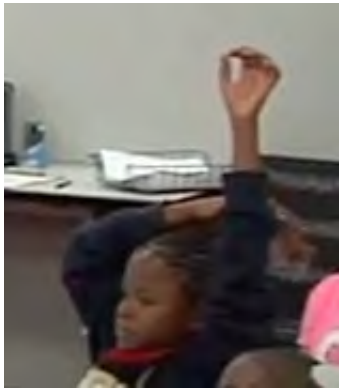
20 in 1:28

Video: Aniyah and Toni

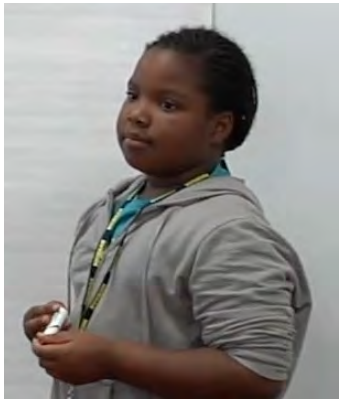


This video and additional supporting materials are available online here.

Using discretionary spaces with care



- Interpreting Toni as asking a real question that she means.
- Hearing Toni's question as central to advancing the mathematical content.
- Reinforcing her mathematical identity, not choosing to read her body as disruptive.

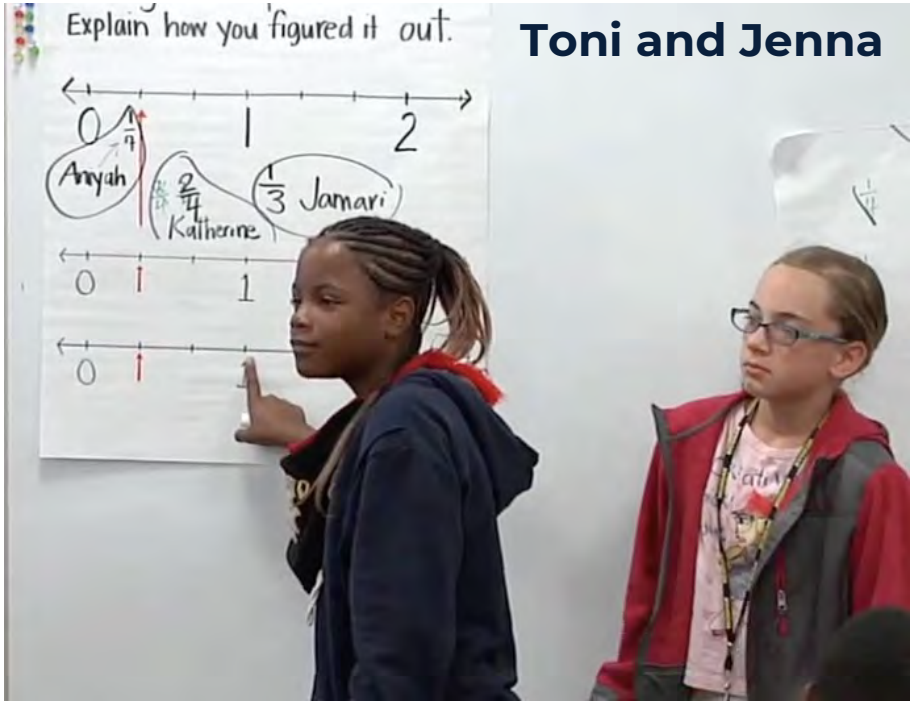


- Interpreting Aniyah as competent to answer questions about her ideas.
- Hearing Aniyah's explanation as central to advancing the mathematical content.
- Reinforcing her mathematical identity, not choosing to read her body as struggling.

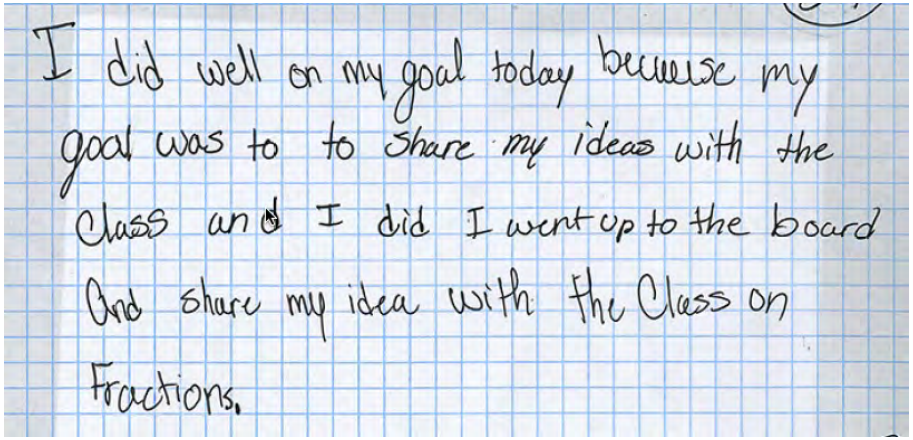
- Other children hear Aniyah as getting the discussion going, and Toni as asking an important mathematical question.
- Aniyah and Toni are both positioned as contributing to the discussion.
- Children see a teacher attending to Black girls as mathematical thinkers and contributors to collective work.

14 minutes after where we stopped

TONI



Aniyah



Moving past “how much” mathematics teachers need

1. Teaching mathematics requires specialized understanding of and fluency with mathematical content.
2. Teaching mathematics requires a dynamic application of mathematical knowledge in context, **combined with** knowledge about students, learning, teaching practices, and equity.

In these examples, what was needed?

- A special kind of mathematical nimbleness and being able to see ideas from someone else's point of view
- An acuity of mathematical listening to hear Aniyah and Toni
- The mathematical insight to disrupt pervasive patterns of interpreting and responding to Black children
- The mathematical depth to use the discretionary spaces to support mathematics learning

A crucial responsibility for mathematics departments

- Teacher candidates learn their mathematics in math departments, so this is where change is needed in the scope and nature of their mathematics learning.
- Math faculty need opportunities to learn this mathematics and approaches to teaching it—examples, ways to assess, homework, class instruction.
- If we are committed to improving K-12 students' learning, working on this must be valued, respected, and rewarded in math departments.

Review: The argument of tonight's talk

1. The premise: K-12 mathematics education is not working for most U.S. young people and this matters.
2. Reforms are, in part, rooted in persistent myths and not in knowledge of what real improvement would take.
3. Improving young people's mathematics learning will depend on valid knowledge about practice and intervention.
4. Math departments have a special responsibility in this endeavor.

Your “exit ticket”: Something to think about

There is an extensive research base for the kind of mathematical knowledge that is needed for the work of teaching.

Why are practices that conflict with this so persistent? What would it take to make change in these?

THANK YOU!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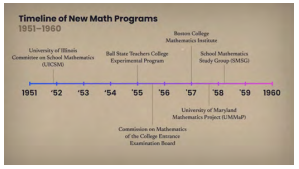
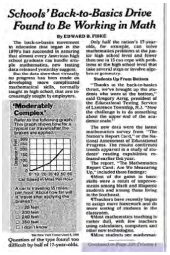


Image on slide 7:
A timeline of new math reform organisations in the 1950s, from "What Happened to 'New Math'?" by Asher Isbrucker, *Medium*, April 20, 2021.
Retrieved from https://medium.com/age-of-awareness/what-happened-to-new-math-eeb8522fc695


Schools' Back-to-Basics Drive Found to Be Working in Math

By EDWARD B. FISKE

'Moderately Complex'

Image on slide 7:
Screenshot of "School's Back-to-Basics Drive Found to be Working in Math," by Edward D. Fiske, *New York Times*, June 8, 1988.
Retrieved from https://www.nytimes.com/1988/06/08/us/schools-back-to-basics-drive-found-to-be-working-in-math.html

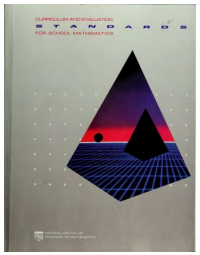


Image on slide 7:
Cover of *Curriculum and Evaluation Standards for School Mathematics*, by the National Council of Teachers of Mathematics Commission on Standards for School Mathematics, 1989.
Retrieved from https://archive.org/details/curriculumevalua00nati/mode/2up

M | EDUCATION

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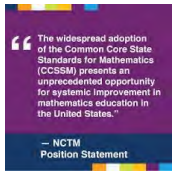

Image on slide 7:
Graphic from "Supporting the Common Core State Standards for Mathematics," by the National Council of Teachers of Mathematics, August 2013.
Retrieved from https://www.nctm.org/ccssmposition/

Image on slide 8:
Cover of *Linear Algebra*, 1965.
Retrieved from https://www.amazon.com/Linear-Algebra-Fundemental-Mathematical-Structures/dp/B002NB51BM

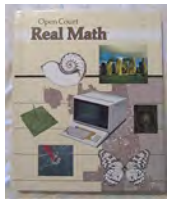

Image on slide 8:
Cover of *Open Court Real Math, Grade 7*, 1991.
Retrieved from https://www.amazon.com/Open-Court-Real-Math-Grade/dp/081260637X

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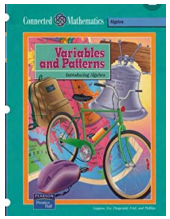

Image on slide 8:
Cover of *Connected Mathematics Variables and Patterns*, 2003.
Retrieved from https://www.amazon.com/CONNECTED-MATHEMATICS-VARIABLES-PATTERNS-STUDENT/dp/0131808168

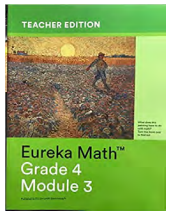

Image on slide 8:
Cover of *Eureka Math, A Story of Units: Grade 4, Module* 3, 2015.
Retrieved from https://www.amazon.com/Eureka-Math-Grade-Module-Teachers/dp/1632553724

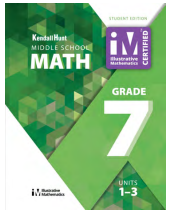

Image on slide 8:
Cover of *Illustrative Mathematics: Grade 7*, 2019.
Retrieved from https://k12.kendallhunt.com/product/illustrative-mathematics-grade-7-student-edition-set

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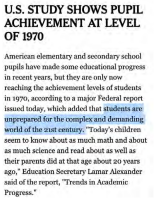
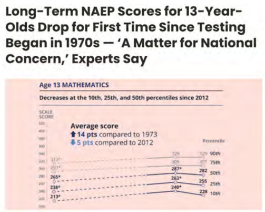

U.S. STUDY SHOWS PUPIL ACHIEVEMENT AT LEVEL OF 1970

American elementary and secondary school pupils have made some educational progress in recent years, but they are only now reaching the achievement levels of students in 1970, according to a major Federal report issued today, which added that students are unprepared for the complex and demanding world of the 21st century. "Today's children seem to know about as much math and about as much science and read about as well as their parents did at that age about 20 years ago," Education Secretary Lamar Alexander said of the report, "Trends in Academic Progress."

Image on slide 9:
Screenshot from "U.S. study shows pupil achievement at level of 1970," by Karen De Witt, *New York Times*, October 1, 1991.
Retrieved from https://www.nytimes.com/1991/10/01/us/us-study-shows-pupil-achievement-at-level-of-1970.html


Long-Term NAEP Scores for 13-Year-Olds Drop for First Time Since Testing Began in 1970s — 'A Matter for National Concern,' Experts Say

Age 13 MATHEMATICS
Decreases at the 10th, 25th, and 50th percentiles since 2012
Average score
14 pts compared to 1973
5 pts compared to 2012

Image on slide 9:
Screenshot from "Long-Term NAEP Scores for 13-Year-Olds Drop for First Time Since Testing Began in 1970s — 'A Matter for National Concern,' Experts Say," by Kevin Mahnken, *The74*, October 14, 2021.
Retrieved from https://www.the74million.org/article/naep-long-term-unprecedented-performance-drop-american-13-year-olds/


Kentucky NAEP Grade 4 Math Proficiency Rates and White Minus Black Achievement Gaps, by Year

Image on slide 9:
Graphic from "What happened to Kentucky's NAEP achievement gaps for math?," by Richard Innes, Bluegrass Institute, October 30, 2022.
Retrieved from https://bipps.org/blog/what-happened-to-kentuckys-naep-achievement-gaps-for-math

Credits

Image on slide 10:
Photo from “What do teachers need this school year? Laura McClure from TED-Ed resolved to find out,” by Laura McClure, TED, September 7, 2016.
Retrieved from https://ideas.ted.com/how-to-help-a-teacher-out/

Image on slide 11:
“Two groups of people arguing and fighting.”
Retrieved from https://www.freepik.com/premium-vector/two-groups-people-arguing-fighting-conflict-among-people-angry-characters-having-argument-disagreement-vector-illustration-colleagues-having-debate-misunderstanding_21715825.htm