Early Mathematics Education: A model for STEM

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Overview

• Why we need Early STEM Education (PreK to Grades 1 or 2), an important part of which is math (my topic)

• Can little children learn math?

• What is Early Math Education?

• What do teachers need to succeed?
Why do we need sound early math education?

- US academic achievement, from K on, is weak relative to other countries
- SES differences in achievement begin early and get worse over time:
  - A recent study shows that the educational gap between rich and poor has grown by 40% since 1960
  - Maryland appears to be an important exception
- It’s not just achievement: it’s attitudes, motivation, feelings
  - After a few years of school, children don’t enjoy math and don’t like learning it
Math is generally taught badly in elementary school and beyond

★ Textbooks are poor
★ Too much testing
★ Too much teaching to tests
★ Too much drill
★ Teachers don’t teach for understanding
★ The situation is especially bad for low-SES children

The educational system is good at teaching many children not to like math
Early childhood?

• In early childhood, we do very little if any significant math education
• Teachers often do not want to teach math
• My ECE student:
  ★“My previous history as a poor math student makes me fear teaching math to young children in the future, that being partially my reason for choosing early childhood education.”
This is unacceptable!

• The situation gives rise to grave educational and moral concerns (which are not new):

  • “Ah, before such dense and willful disregard of the life which is growing within these children, we should hide our heads in shame and cover our guilty faces with our hands!” Maria Montessori

• For Montessori, math learning is natural for children and failing to foster it is neglect—really a moral issue as well as educational and economic
Many responses

- Parents, particularly low-SES, want preschools to prepare children for school and want effective schooling.
- Professional reports:
  - Joint position statement of NAEYC/NCTM
- Federal and State initiatives
  - Head Start focus on early learning
  - At least 40 states doing some form of EME
  - New Federal funding
- Everyone wants the children to succeed, but...
Pressure!

- Pressure to push down elementary school teaching (which isn’t very good!) to early math education

  ★ Test, test, test

  ★ Drill, drill, drill

- This is inappropriate for early childhood

- Why do it when it doesn’t work even for older children?

- So we need appropriate math education in the spirit of Montessori, fostering the life which is growing within these children

- Our learner-centered approach to early childhood math can serve as a model for STEM and also for those educating
But some questions

• Are young children *ready* to learn math?
• What are the *goals* of early math education?
• What is the *content*?
• What kind of *experiences* (from play to curriculum) can help children learn math?
• How can you *teach* early math without pressuring young children?
• How can we *help* teachers to do this?
Ready to learn math?

- Children’s math thinking is

  ★ Comprehensive

  ★ Complex (competent/struggling, and concrete/abstract)

  ★ And involves language and metacognition

- Some examples:
What does this teach us?

- Children are already mathematicians and engineers
  - Readiness for math learning is not an issue
  - They are already doing real math (not written, usually)
  - Their thinking is more complex and competent than many think
  - Language and self awareness is crucial

- EME is both possible and desirable:
  - It can draw on children’s abilities and interests
  - It need not be an imposition
  - It is “developmentally appropriate”
  - They can enjoy it!
  - And it can include an integration with other STEM subjects and literature too
What are the goals of EME?

- One goal: Prepare for the future

  ★ “…mathematics education for 3- to 6-year-old children is a vital foundation for future mathematics learning.” (NCTM/NAEYC)

- Early performance predicts later achievement

  ★ Maeroff: “…it is much easier not to be left behind if you don’t start behind”

- But a big problem: testing and pressure

- Therefore…
Second goal: The present

- Don’t sacrifice the present for the future

- Math is one of children’s earliest intellectual interests and can be fun

- Provide enjoyable and inherently valuable early math learning experience NOW

- Start to show them what comprises real math learning
Third goal: The outer and the inner

- Think also about motivation and its effects
- Make sure the children look and feel as smart as they are

- The result:

★ Teacher expectancy
★ Student confidence
What is the content of EME?

- Subject matter:
  - number and operations, but also,
  - shape,
  - pattern,
  - space,
  - measurement,
  - logic

- Math is much more than "numeracy"
Analyzing shapes: why is this a triangle?

Ideas like how many and what makes more

Strategies for adding

Detecting patterns

Logic: “This must be true because…”

Verbalization: “I did it by…”

Math involves language and literacy

Not only written

Not trivial or baby-like

In fact, it’s deep
• We usually name things:

• lion  bus  icky

• But when we count, the words “one, two, three” are used in a new way.

★★ Lion is one or three or even two.

★★ Three is not just the icky, but the set as a whole.

• The number words are strange and new and a wonderful mystery
But kids like mysteries

• Spontaneous interest: what is the biggest number?

• Early math education can grow from what children already know

• This means it should not be trivial
What kind of experiences are useful?

- Everyone agrees:

  ★ Provide a rich environment

  ★ Lots of concrete experiences (to promote abstract ideas— not manipulatives for their own sake)

  ★ Encourage play

  ★ Build on play: “the teachable moment”
Play is essential, but:

- Children don’t learn enough from play--don’t “mathematize”
- The teachable moment is hard to do
- It’s unfair to ask teachers to rely on it as the primary approach
- To achieve our goals, particularly for kids in difficulty, we also need:
Planned experiences

• Organized “projects” in math, science, engineering and using technology if possible

★ For example: map of the room

★ Rochel Gelman science activities

• But these too are not enough

★ They don’t cumulate

• We need curriculum too
What is curriculum?

• Many assume that curriculum means the didactic approach:

★ Rote learning

★ No flexibility

★ Imposition

★ Boring
In other words...

- They think that:

  ★ Early math education in general and curriculum in particular must be as bad as what they experienced in elementary school

  ★ Math involves meaningless symbolic activities

  ★ Early math education is the stuff of our worst nightmares

- Thus from the web:
• Math Tutor NYC - Help Your Child Get Rid of His Mathematical Nightmares

• Sweet asleep in his land of dreams, your child is already set to enter the gates of fairyland. In a moment’s time, creepy creatures that look like numbers swallow him up. Your little one is zapped to reality and has a confrontation with his most dreaded subject- Math. The only respite that comes here is that your child is not the only one who has such nightmares.
But: My dinner with Marilyn

- She is a teacher of dance to young children (and older too)

- She advocates play because schools are getting more and more rigid and depriving kids of play and creativity

- She is resistant to the idea of an early math curriculum

- But…
She reports that...

- Her dance lessons have a theme
- They are planned
- They are sequenced over a several week period
- They last around 45 minutes
- There is a lot of practice and some drill
- Kids cannot do anything they want to do
- But they can elaborate in creative ways on what is taught
- They move around
- They enjoy themselves
My question then is:

• Couldn’t a math curriculum be just like a dance curriculum?

• Why do we dread the former and love the latter?

• The answer:

★ We have had miserable experiences with math

★ But we soar with Billy Elliot
BILLY ELLIOT
THE MUSICAL

ELTON JOHN
LEE HALL
STEPHEN DALDRY
A curriculum should be:

- Activity based
- Organized-- every day (20-40 minutes)
- Sequenced: a developmental trajectory
- Comprehensive-- number, shape, space...
- Interesting and playful
- Challenging--count to 100, hexagon
- Rigorous-- ideas, memory, procedures
- Expressive-- requires talk and explanation
- Informal and formal, concrete and symbolic
Settling on a curriculum

- You have to choose one or create one
- It’s very hard for teachers or anyone else to create one!
- Several are available:
  - Big Math for Little Kids (Ginsburg, Greenes, and Balfanz)
  - Building Blocks (Clements and Sarama)
  - High Scope (Epstein)
  - Number Worlds (Griffin)
- An example:
Big Math for little kids

- Developed over 4 years with NSF support

- Based on our research and the broader research literature.

- For ages 4 and 5

- Used in Singapore too!
Instructional Program

• Separate programs for pre-kindergarten and kindergarten
• Six units:
  ★ Number
  ★ Shapes
  ★ Patterns
  ★ Measurement
  ★ Operations on number (addition, subtraction)
  ★ Space
• Storybooks, one per unit
• Assessment program
• And planning—that is, a curriculum
<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Pg.</th>
<th>Weeks</th>
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<tbody>
<tr>
<td>1</td>
<td>Count, Clap, and Stomp</td>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Show Me</td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Henrietta Sees Numbers</td>
<td>4</td>
<td>X, X</td>
</tr>
<tr>
<td>4</td>
<td>Bag It!</td>
<td>6</td>
<td>X, X, X</td>
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<tr>
<td>5</td>
<td>Did I Make a Mistake?</td>
<td>8</td>
<td>X, X</td>
</tr>
<tr>
<td>6</td>
<td>Find the Match</td>
<td>9</td>
<td>X, X</td>
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<tr>
<td>7</td>
<td>My Number Book</td>
<td>11</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>What Comes Next?</td>
<td>13</td>
<td>X, X</td>
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<tr>
<td>9</td>
<td>Number Match</td>
<td>15</td>
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<td>10</td>
<td>Numbers With Pizzazz!</td>
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<tr>
<td>11</td>
<td>Let's Line Up!</td>
<td>22</td>
<td>X</td>
</tr>
<tr>
<td>12</td>
<td>If You're Happy and You Know It</td>
<td>24</td>
<td>X</td>
</tr>
<tr>
<td>13</td>
<td>Animal Parade</td>
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<td>14</td>
<td>Tell a Story</td>
<td>28</td>
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<tr>
<td>15</td>
<td>A Fishy Game</td>
<td>29</td>
<td>X, X</td>
</tr>
</tbody>
</table>

**Key**

- The Unit Storybook is introduced.
- The Take-Home Game may be sent home after completing this activity.
- This activity may be used for Focused Assessment.
math without pressuring young children?

• Implementing a “lesson” in a curriculum

★ An example from measurement
What does it show?

- Group engagement
- Children’s fascination and motivation
- Teacher-led
- Teacher use of language
- Lots of open-ended questions
- Kids challenged to think: she assumes they can
- Real objects
- Nothing written
- Can be pursued further in small groups or individually
- Integrates with science
Curriculum

• So a curriculum can be a planned sequence of exciting activities, operating every day to stimulate children’s thinking and motivation in the spirit of Montessori and the great progressive educators

• But it’s not easy to do this!

• Therefore…
• Professional development

• Professional development,

• Professional development!
We need to support teachers

- Good college level preparation: a course in young kids and math education (and overcoming fears)

- In-service

★ Focused on teaching a specific curriculum

★ Lesson study

★ Lots of supervision and coaching

★ And then teachers can do the teachable moment and be flexible and creative.
In conclusion

• We need sound early math and STEM education

• Children are more than “ready” for it

• Our goals should include the future, the present, the inner and the outer

• The math to be taught is broad and deep

• We should encourage play, projects, and curriculum

• Teachers need preparation and support

• And finally…
• Thank you!

• For further information contact

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