Supporting Early Mathematics with Creative Investigations Based on Best Practices

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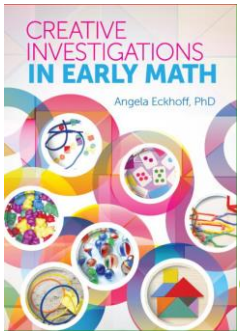
In this session we will explore how to support teachers to:

- Identify the links between mathematics content and inquiry-based learning in order to develop cooperative mathematics lessons that will engage all children in their classrooms
- Recognize and appreciate children's mathematics thinking in order to build upon their current understandings
- Document and evaluate children's knowledge development with rich, meaningful classroom work samples

Empowering Teachers to Eliminate the Opportunity Gap

Using intentional pedagogical practices, teachers can create early childhood classrooms that honor the ways in which children learn, explore, and play. Through careful observation, we can document children's' current stages of understanding, you can scaffold their thinking by questioning, supplying materials that encourage experimentation, and providing opportunities for guided learning.



Early Mathematics: Opportunity is Key

- **National Council of Teachers of Mathematics' (NCTM) Position Statement -** Closing the Opportunity Gap in Mathematics Education (2012)
- All students should have the opportunity to receive high-quality mathematics instruction, learn challenging grade-level content, and receive the support necessary to be successful. **Much of what has been typically referred to as the *achievement gap* in mathematics is a function of differential instructional opportunities.** Differential access to high-quality teachers, instructional opportunities to learn high-quality mathematics, opportunities to learn grade-level mathematics content, and high expectations for mathematics achievement are the main contributors to differential learning outcomes among individuals and groups of students.

Empowering Teachers to Eliminate the Opportunity Gap

Mathematics is a product of human beings.

'The subject matters of mathematics – arithmetic, geometry, probability, calculus, set theory, combinatorics, game theory, topology, and so on – arise from human concerns… In other words, mathematics is fundamentally a human enterprise arising from basic human activities' (Lakoff & Nunez, 2000).

Flexible, Inventive, and Persistent Thinking

- The early childhood years are a time to build a solid foundation in mathematics.
- Early childhood educators are responsible for developing engaging and encouraging classrooms
  - Young children's experiences with mathematics impacts their confidence in their ability to understand and use mathematics
- Early, positive experiences help children to develop dispositions such as curiosity, imagination, flexibility, inventiveness, and persistence, which contribute to their future success in and out of school environments (Clements & Conference Working Group, 2004).

POLL

Building a Supportive Context

- The disconnect between university-based and school-based components of teacher education programs has been well-documented as a central issue facing teacher preparation programs for many years (Vick, 2006; Zeichner, 2010)
- Environmental barriers faced by pre-service teachers as they aim to incorporate creative lessons encompass such categories of **incongruent mentor teacher beliefs**, **scripted or preplanned curricula use**, **limited access to materials/manipulatives, limited time allocated for lesson implementation**, and **incongruent administrative expectations** (Eckhoff, 2011)

Learning community model/community of practice (Lave & Wenger, 1991; Vescio, 2008) to support pre-service and in-service teachers reflect, evaluate, deconstruct, experiment, and reconstruct their experiences teaching mathematics.

Begin at the Beginning: Beliefs and Knowledge Inventories

MTEBI (Enochs, Smith, and Huinker, 2000)
Knowledge of Mathematical Development Survey (Platas, 2008)

Beliefs Inventories – Supporting Reflective Practice

1.	When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	SA	A	UN	D	SD
2.	I will continually find better ways to teach mathematics.	SA	A	UN	D	SD
3.	Even if I try very hard, I will not teach mathematics as well as I will most subjects.	SA	A	UN	D	SD
4.	When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA	A	UN	D	SD
5.	I know how to teach mathematics concepts effectively.	SA	A	UN	D	SD

MTEBI (Enochs, Smith, and Huinker, 2000)

Teacher Learning Community Model

- Selection of a common problem or theme.
- Can come from teachers' own experiences in the classroom
- Open and guided discussion
- Whole group participation
- Virtual or face-to-face meetings

- Presentation of the problem, small or whole group deconstruction/discussion, problem-trying, development of a plan.
- Cycle repeats following the implementation of the reconstructed lesson

Play, Reggio, and Loose Parts

- Connecting mathematics education to accepted, recommended, and emerging pedagogical practices in early childhood

- *Playful Engagement*
- *Math as a Language for Understanding and Expression*
- *Environment as Teacher*
- *Teacher as Facilitator, Guide, Provocateur*
- *Hands on, Minds on work*

Reggio Emilia

"…it is not an imposition on children or an artificial exercise to work with numbers, quantity, classification, dimensions, forms, measurement, transformation, orientation, conservation, and change, or speed and space, because these explorations belong spontaneously to the everyday experiences of living, playing, negotiating, thinking and speaking by children."
(Gandini, 2011)

The Theory of Loose Parts -

www.aneverydaystory.com

*'In any environment, both the degree of inventiveness and creativity, and the possibility of discovery, are directly proportional to the number and kind of variables in it. '(*Nicholson 1972)

What does Creativity Look Like in Early Childhood

- Freedman (2010), writing on creativity in the arts, proposes seven important characteristics of creativity in context:
  "Creativity
  - (1) involves critical reflection,
  - (2) is based on interest,
  - (3) is a learning process,
  - (4) is functional,
  - (5) is a social activity,
  - (6) depends on reproduction, and
  - (7) is a form of leadership" (p. 10).

Possibility Thinking – A Dynamic Interplay between Children and Teachers (Craft, et.al., 2012)

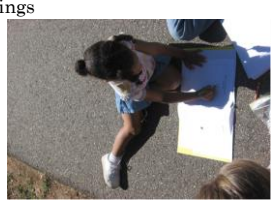
- **Posing Questions** – questions from children are acknowledged and celebrated by teachers. Teachers' questions encourage inquiry
- **Play** – opportunities for extended play periods
- **Immersion** – immersion in a "benign environment" free from criticism and mockery (caring & positive)

Possibility Thinking cont.

- **Innovation** – Teachers closely observe innovations in student thinking in order to prompt and encourage (formative assessment)
- **Being imaginative** – ample opportunities to meld imagination and curriculum content
- **Self-determination and risk taking** – deep involvement and risk-taking are encouraged by both children and teachers

Creative Investigations Include:

- Open-ended Tasks
- Social Interactions in Pairs/Small Groups
- Opportunities for Children to Reflect
- Repeated Opportunities to Explore and Elaborate on Past Understandings



Extended Opportunities to Engage with Mathematics

- A mathematics center can support children's opportunities to:
  - Explore and learn based on learner interests
  - Engage in discovery and construction of meaning,
  - Extend activities from the lessons
  - Explore concepts from the lessons or related concepts in depth
  - Connect mathematics to daily experiences

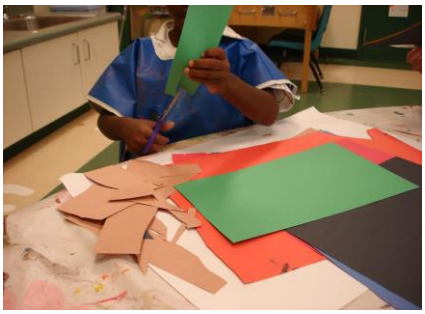
Promoting Guided Inquiry and Creative Math Learning

Classroom Components	Teacher Actions
Physical environment	• Thoughtfully include a variety of manipulatives, blocks, natural materials, and digital media for free exploration.
Role of the teacher	• Develop a supportive environment for playful learning, experimentation, and risk taking. • Closely observe children's play and exploration, using formative assessments. • Ask thoughtful questions and provide provocations to expand and clarify children's thinking.
Relationships among peers	• Provide opportunities for collaborative experiences. • Demonstrate respect for children's work. • Promote opportunities for play and exploration.
Structure of mathematics lessons and experiences	• Provide opportunities for individual and group experiences. • Maintain flexible scheduling for lesson lengths based on children's responses and interests. • Provide for repeated mathematics experiences. • Promote opportunities for children to make their thinking visible (using concrete manipulatives, STEM journals, digital photography, and so on). • Extend familiar lessons and concepts to build proficiency and flexibility of student understanding.

Does the Task Offer Challenge, Creativity, and Inventiveness?

- Problem is sufficiently complex to meet a variety of understanding levels and learning styles
- Working in groups or pairs
- Takes time
- Materials/Manipulatives support and challenge thinking
- Documentation of student understanding (STEM student journals, photographs, ch

Paper Structures – Mixed Media: Integrating the Arts and Mathematics



Working Side-by-Side

Circles Inside Circles

Finished Work – Circles, Squares, Triangles, & Rectangles

Big and Little Nature Hunt (Eckhoff, 2017)

Topic: Comparing Length

Questioning – As children collect big and little objects, talk with then about their findings and encourage them to find additional objects to compare.

Ask questions such as "How do you know that is the bigger leaf?" or "What makes you say that leaf is little?" These types of guided-inquiry questions can support their thinking and provide opportunities for you to gauge their understandings.

Questions to Promote Inquiry and Exploration (Eckhoff, 2017)

- How do you know this shape is a triangle?
- Is that shape the same as this one? How are they the same/different?
- What shape could you make if you combined these shapes together?
- Have you ever seen a shape like this before? Where?
- Would your shape roll? Bounce? Stack on top of others?
- What would we need to do to change this square into a rectangle? Circle into an oval?
- How can you use the scissors to cut this square into a triangle? What will you need to cut away?

GEOMETRY: 2D AND 3D SHAPES (ECKHOFF, 2017)

- **Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships**
- **NCTM Pre-K–2 Expectations**: In pre-K through grade 2 all students should—
- recognize, name, build, draw, compare, and sort two- and three-dimensional shapes;
- describe attributes and parts of two- and three-dimensional shapes;
- investigate and predict the results of putting together and taking apart two- and three-dimensional shapes.

- Squares form the base for a cube and pyramid
- Rectangles form the sides of a triangular prism
- Triangles form the sides of a pyramid and the ends of a triangular prism
- Circles form the ends of a cylinder

GEOMETRY: *PHOTOGRAPHING A SHAPE WALK* (ECKHOFF, 2017)



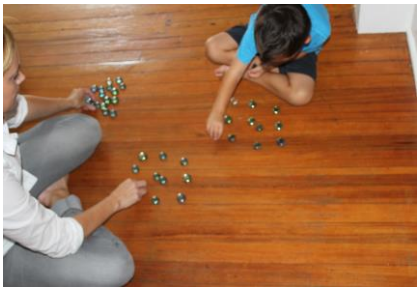

GEOMETRY: SPATIAL VISUALIZATION (ECKHOFF, 2017)

- **Apply transformations and use symmetry to analyze mathematical situations**
- **Pre-K–2 Expectations**: In pre-K through grade 2 all students should—
- recognize and apply slides, flips, and turns;
- recognize and create shapes that have symmetry.

Spatial visualization is the ability to engage in shape transformations, including making them symmetrical, rotating them, and flipping them.

- A shape is symmetrical when it can be divided into two identical pieces.
- When a shape is flipped over a line, it can produce its own mirror image.
- When an object is rotated 360 degrees on a rotational point, it will return to its original position.

Geometry: *Can You Build This: Symmetric Play* (Eckhoff, 2017)



STEM Journals for Documenting Thinking and Explorations

MATH JOURNAL	
WHAT I OBSERVED:	WHAT I THINK:

Including High-Quality Mathematics Focused Children's Literature

Below are three essential questions to consider before introducing math focused children's literature into the classroom:

1. Does the book incorporate high quality artwork/pictures and text?

2. Does the book present content that is technically sound and appropriate for children's developing understandings?

3. Is the book effective for helping students build both inquiry and content understandings?

Policy & Practice Recommendations

- Trained early educators with both content and pedagogical content knowledge in STEM disciplines:
  - Pre-service teachers working in integrated STEM courses with supervised field experiences
  - Integration of learning community models in pre-service education with the serious consideration of the college/university role during the critical induction years for graduates
- Continued advocacy work that promotes an image of the child that reflects the multiplicities of children and childhood that positions them as rich, competent, and complex social actors
- Continued support for a democratic approach towards early childhood that attends to socially-just educative practices that recognize the many modalities by which children learn, express, and communicate

Thank You

- Any questions, email: aeckhoff@odu.edu

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