RESEARCH

Promoting STEM with the Full Range of Learners: Using Ramps & Pathways

by Shelly Lynn Counsell

Early childhood classrooms using a constructivist approach have long provided young children with important opportunities to build their own content knowledge through active exploration, make sense of their surroundings, and use what they learn to design and create something new (Brooks, 2011). "Ramps and Pathways" is an approach to physical science that is guided and informed by constructivist theory. The use of specific materials is encouraged for the study of movement of objects along ramps and pathways. R&P was developed by the Regents' Center for Early Developmental Education at the University of Northern Iowa and supported by a grant from the National Science Foundation to pilot and field test it. The pilot study and field-testing were conducted over three years in three states with 42 teacher participants. While few studies have examined the participation of young children with special needs in inquiry-based learning in science, this study included young children with disabilities in both self-contained and inclusive settings. The findings from field-testing confirm two key points that hold promise and relevance for early childhood administrators, educators, professors, and parents:

- The Ramps & Pathways approach, under the right conditions within formal and informal constructivist educational settings, demonstrates that children with disabilities are quite capable of engaging and applying scientific concepts and relationships within diverse social settings.
- Educators (and potentially parents) can promote children's scientific thinking and understanding during R&P explorations and investigations through the use of productive questioning to support the inquiry teaching-learning process according to the child's agenda (i.e., problems the child wants to solve and questions the child wants to answer).

Shelly Lynn Counsell, EdD, is an assistant professor and early childhood education program coordinator at the University of Memphis and teaches the Planning and Facilitating Math and Science course. She was an R&P site facilitator and a research fellow at the UNI Regents' Center. She has presented R&P and other early science workshops locally, nationally, and internationally. She co-authored an R&P chapter in NSTA's Exemplary Science PD text, she is a co-author on the Teachers College Press book, *STEM Learning with Young Children: Inquiry Teaching with Ramps and Pathways*, and has published R&P related articles in Science & Children.

Although constructivist theory is not new to early childhood, it is now widely accepted as a key approach that underpins contemporary science education perspectives. R&P investigations place an emphasis on knowledge as something that is actively constructed rather than passively transmitted. R&P encourages young children to construct STEM knowledge, understanding, and relationships as they actively engage with materials, sharing and interpreting their experiences in physical and social worlds. Therefore, R&P serves to further confirm the value of using constructivist theory to inform best practices to promote children's learning and development. As young children build ramp structures and pathways with lengths of cove molding, they release marbles on their structures (exploration and investigation), and observe what happens. During R&P investigations, young children actively experience and develop practical understanding of Newton's

BRIDGING RESEARCH AND PRACTICE

The Bridging Research and Practice feature in each issue includes an article on an aspect of early childhood research plus links to the original published research with a companion article full of practical strategies for how to implement the research in your practice.

We encourage you to nominate research for review by the Research Advisory Team by email:
PamB@childcareexchange.com
To learn more about the Advisory Team, visit
www.ChildCareExchange.com/research

laws of force and motion in relation to inclines (DeVries & Sales, 2011; Counsell, Uhlenberg, & Zan, 2013; Zan & Geiken, 2010).

As part of the research, a Ramps and Pathways Implementation Checklist was developed by an external evaluator in consultation with the project staff to identify seven characteristics that the R&P developers considered to be particularly important to successful R&P implementation (see Table 1). While most of the items were found in the majority of classrooms, some of the teachers struggled with some aspects of the project — particularly the teachers in the pilot study as compared to the field study.

Table 1 — Ramps and Pathways Implementation Checklist

Checklist Item	% Yes Pilot (n = 19)	% Yes Field (n = 23)
Provides materials as described in the R&P curriculum (variation in R&P materials)	100% (19)	100% (23)
Schedule accommodates curriculum	100% (19)	96% (22)
Arranges furniture so children have adequate room to work	100% (19)	96% (22)
Models curiosity, play behavior, and uses of different tools	47% (9)	83% (19)
Encourages inquiry	21% (4)	87% (20)
Documents observations during R&P time	21% (4)	65% (15)
Uses documentation for discussion	11% (2)	61% (14)

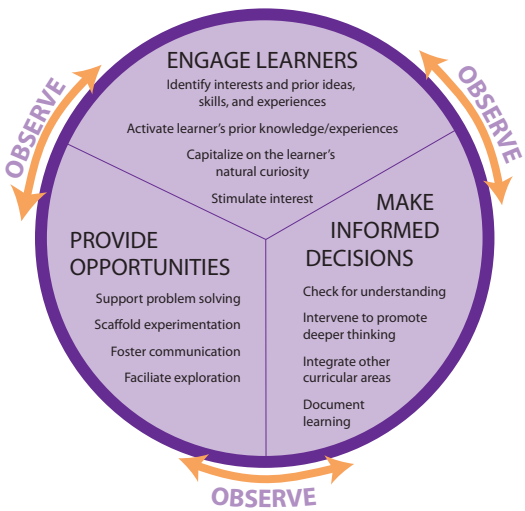
Source: Counsell, Uhlenberg, & Zan, 2013.

The significant increase in teachers' documented use of inquiry during R&P field-testing likewise corresponded with the teacher reflections reported during monthly community meetings in southeast Idaho. Seven southeast Idaho teacher participants (Pre-K through 2nd grade) included an early childhood-special education teacher in a self-contained setting as well as one kindergarten teacher and one second-grade teacher within inclusive public school settings who reported benefits using productive questioning during R&P with the full range of learners (including children with disabilities). The article, "Science Learning for ALL Young Scientists: Exploring, Investigating, Learning, and Growing Together with Ramps and Pathways in Diverse Settings" (Counsell & Wright, 2016) highlights the three teachers' experiences using R&P during center time or science instructional time.

To illustrate the clear benefits of using productive questioning to guide and support children's scientific thinking during R&P explorations, the early childhood-special education teacher's testimonial regarding one child's experience with R&P was featured. In this scenario, the child (who was diagnosed with cognitive delays) created a pathway that included a block with a hole in the center. The child wanted the marble to pass through the block. The child placed the block flat on the ground. The teacher carefully observed the child's repeated actions and asked productive questions, e.g. What did the marble do? What did you want the marble to do? Can you show me?

The gathered information enabled the teacher to determine the child's agenda and assess the child's understanding and scientific reasoning. This process, in turn, helped the teacher to identify the child's zone of proximal development. These insights were then used to scaffold the child's scientific reasoning and spatial awareness with possible modifications and accommodations (such as using tubing inserted through the hole) that helped the child to visually track the marble's trajectory through the hole to identify the problem and figure out a solution. Qualitative data like this teacher's experience — collected from teachers during the pilot testing and field-testing — helped the R&P researchers develop a conceptual framework known as the Inquiry Teaching Model, designed to capture the inquiry teaching-learning process (see Figure 1).

Figure 1 — Inquiry Teaching Model



(*STEM Learning with Young Children: Inquiry Teaching with Ramps and Pathways*, p. 15)

Supporting and promoting children's explorations and investigations using R&P increases *all* children's access to STEM teaching and learning, especially within diverse, inclusive

settings that capitalize on mixed-ability groupings (including more advanced ramp builders) who can also serve as peer mediators. The Inquiry Teaching Model encourages teachers to employ timely interventions informed by firsthand observations (ongoing assessment) during R&P activities to support children's scientific thinking (e.g. predicting, evaluating, and problem solving,) and carefully scaffold children's thinking and learning using productive questioning in an ongoing, spiraling, inquiry teaching-learning process. The learning and developmental benefits of early science experiences like R&P physical science activities with young children are evident (Counsell et al., 2016). Preliminary results are encouraging and warrant further study.

References

Brooks, J. G. (2011). *Big science for growing minds: Constructivist classrooms for young thinkers*. New York: Teachers College Press.

Counsell, S., Escalada, L., Geiken, R., Sander, M., Uhlenberg, J., Van Meeteren, B., & Zan, B. (2016). *STEM learning with young children: Inquiry teaching with Ramps and Pathways*. New York: Teachers College Press.

Counsell, S., Uhlenberg, J., & Zan, B. (2013). Ramps and Pathways early physical science program: Preparing educators as science mentors. In R. Yager, S. Koba, and B. Wojnowski (Eds.), *Exemplary science: Best practices in professional development* (2nd ed., pp. 143–156). Arlington, VA: National Science Teachers Association Press.

Counsell, S. L., & Wright, B. L. (2016). Science learning for ALL young scientists: Exploring, investigating, learning, and growing with Ramps and Pathways in diverse settings. *Childhood Education, 92*(5), 365–372.

DeVries, R., & Sales, C. (2011). *Ramps & Pathways: A constructivist approach to physics with young children*. Washington, D.C.: National Association for the Education of Young Children.

Zan, B., & Geiken, R. (2010). Ramps and Pathways: Developmentally appropriate, intellectually rigorous, and fun physical science. *Young Children, 65*(1), 12–17.

For more information, contact: Beth Van Meeteren, Director, Regents' Center for Early Developmental Education, University of Northern Iowa at beth.vanmeeteren@uni.edu or call (319) 273-2550. Visit the Ramps and Pathways website at www.uni.edu/rampsandpathways/

PRACTICE

Inquiry Teaching Supports ALL Children's STEM Learning

by Janet Thompson

Early childhood educators have long observed that young children learn most readily through their own active engagement with the people and materials in their immediate environment. Researcher Shelly Counsell brings life to this constructivist approach through her work with the Ramps & Pathways project, in which a diverse sample of teachers and children engage in active inquiry to explore some of the basic concepts of physical science. Using simple materials and specific practice guidelines, participating teachers facilitated children's questioning, experimenting, refining and, finally, documenting of their own ideas and discoveries. All children, including those with developmental disabilities, were able to gain new skills and understandings through their active participation in the project.

The STEM fields can often seem daunting to early childhood educators and families, who may feel that they themselves have inadequate background knowledge to support children's learning in these areas. The following strategies can help alleviate potential anxieties:

Photo by Mary Lynn Spiker, Kindergarten Teacher at Claude A. Wilcox Elementary and 2017 Idaho State Teacher of the Year

Teacher Educators

To increase pre-service teachers' comfort level with the concepts, methods, and vocabulary common to the STEM fields, try the following:

- **Introduce materials** — such as the ramps, balls, and blocks used in this project — to your college students and ask them to explore and investigate the materials to help them recognize and understand their physical properties and capacities. As they begin to enjoy this playful process, encourage them to ask questions and test their ideas. This kind of experiential exercise, using varying materials, will need to be repeated multiple times before it becomes a natural part of students' approach to planning curriculum for young children.

- **Encourage students to think of themselves as 'co-explorers' with children**, particularly when experimenting with concepts and skills in the STEM curriculum domains. Help them define their adult role in children's 'productive play,' observing the children's interests and extending their explorations of materials and processes with productive questions.

- **Teach the conceptual foundations**, as well as the specific strategies for scaffolding young children's learning, within a constructivist framework. Emphasize that simply providing materials does not equate with concept learning or skill development, and that intentional teaching and time for extended experimentation are required in order for children to translate concrete experiences into generalizable knowledge.

Janet Thompson, MA, is director of the Early Childhood Lab School at the University of California, Davis Center for Child and Family Studies. As an educator, her interests focus especially on the growth of social and emotional competency and its contributions to early learning. She was a primary author of California's Preschool Learning Foundations and Curriculum Frameworks for Social-Emotional Development and Social Sciences Frameworks.

- **Demonstrate using inquiry teaching practices** like productive questioning to support scientific thinking and understanding during pre-service teachers' active exploration and investigations with Ramps and Pathways. Support their practice using those techniques as well.

- **Familiarize your college students with basic STEM vocabulary** to increase their confidence and enable them to contribute to children's scientific and mathematical literacy.

Administrators and Teachers

Venturing into the world of STEM learning is challenging for many early childhood educators, who may have grown up feeling they were "not good at math." Changing these attitudes in adulthood can be difficult. A program administrator and other pedagogical leaders can play a crucial role in several ways:

- **The same strategies that are effective with pre-service teachers can be important tools for changing the mindsets and practices of teachers already working in the field.** Structure professional development times when teaching teams can handle and play with open-ended materials. Practice incorporating STEM vocabulary into adult-child conversations, as well as responding to children with productive questions and comments that will broaden and deepen their inquiry.

- **Set a positive tone of program support for inquiry-based learning by displaying to teachers your own willingness to learn through trying multiple solutions to a problem.** Invite others to join you in sharing stories of figuring out how to do something new through trial and error. Help teachers and other classroom adults observe that learning occurs through the process of experimentation and not just at that "Aha!" moment when an optimal solution to a problem is found.

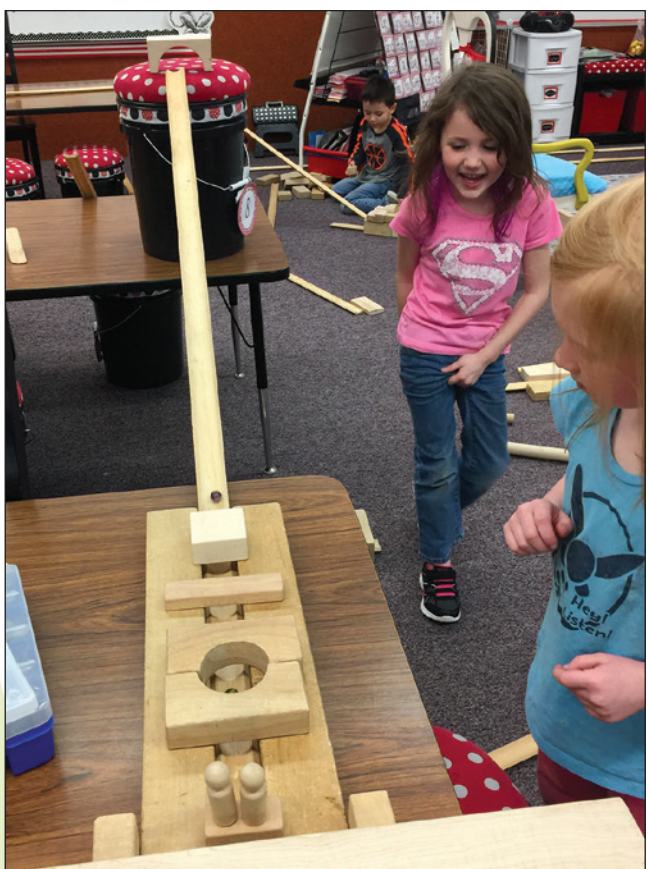


Photo by Mary Lynn Spiker, Kindergarten Teacher at Claude A. Wilcox Elementary and 2017 Idaho State Teacher of the Year

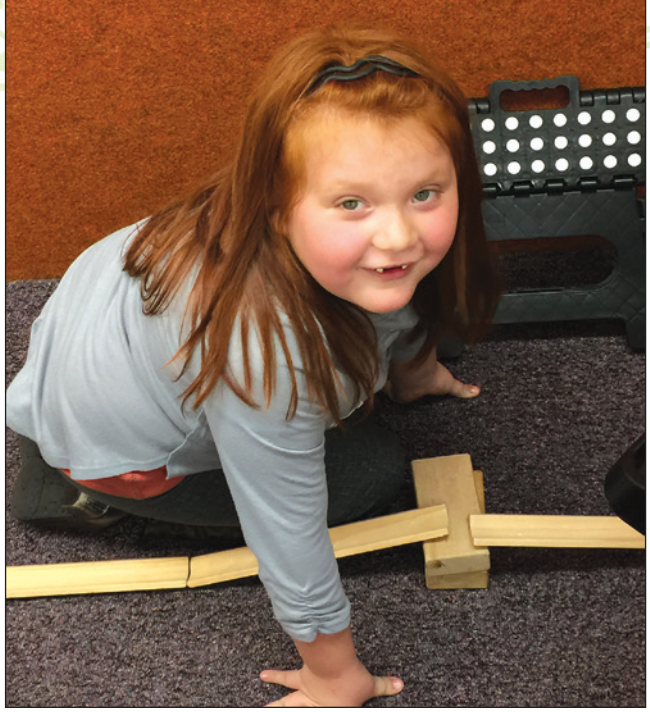


Photo by Mary Lynn Spiker, Kindergarten Teacher at Claude A. Wilcox Elementary and 2017 Idaho State Teacher of the Year

Note the JOY and complete satisfaction experienced as children experience team building, figure out solutions to problems, and answer questions that arise during explorations and investigations.

- **Provide 'loose parts' as regular features of both your indoor and outdoor program environments and display them in inviting ways alongside other classroom materials.** Incorporating non-standard, open-ended items can spark curiosity and prompt more creative play and problem solving. Nature items are especially well suited for this.

- **Provide teachers with the tools to document children's project work**, including cameras and photo display supplies and templates. Emphasize the importance of including images and dictation or description from all children in classroom documentation. Model ways to share documentation with children during group times, emphasizing everyone's contributions and consolidating the concept learning that has evolved over the course of children's explorations.

- **Show your enthusiasm about teachers' and children's STEM inquiry and your support for teachers' extra efforts.** Changing attitudes and practices in unfamiliar territory is hard work!

Families

Family members will also benefit by being included in their young children's STEM journeys. Here are suggestions for collaborating with families so the learning and excitement can extend beyond the school day.

- **Consider hosting a Families Play event at school.** Feature several stations around the indoor or outdoor space where related materials are available to combine for building, measuring, counting, connecting, and simply exploring. Teachers and other program adults can circulate to talk about how children have been experimenting. Post STEM-related words children are learning so their families can become familiar with the new vocabulary and concepts.

- **While an exploration like Ramps & Pathways is underway at school, send home ideas about complementary activities families can do together.** Hunting for ramps at home and in the neighborhood is an active way to start. It becomes even more exciting for children if they can take a photo of their discovery to share with the class.

- **Share a list of children's books featuring STEM-related themes that families can find at the public library.** Let them know which books you have read with children at school so they can look for already-familiar favorites. This gives young children an opportunity to be experts as they reread a book with family members and describe their related school explorations.

- **Ask families to send the teacher photos of themselves or their children engaged in STEM-related activities** such as working at a computer, measuring ingredients, examining nature discoveries or following assembly instructions. These bring STEM activities to life.

When families have tangible ways to participate in their children's learning, they can become eager partners in their children's STEM journeys. What may have initially seemed daunting can instead become both accessible and exciting.

Build a Program Library of Books that Offer Concrete Ideas and Photos of Early STEM Learning in Action

Ramps & Pathways (Rheta DeVries and Christina Sales)

Making & Tinkering with STEM (Cate Heroman)

Mathematizing: An Emergent Math Curriculum Approach for Young Children (Allen C. Rosales).

Young Investigators: The Project Approach in the Early Years, 2nd Edition (Judy Harris Helm & Lilian Katz)

Worms, Shadows, and Whirlpools: Science in the Early Childhood Classroom (Karen Worth & Sharon Grollman)

Inspiring Young Minds: Scientific Inquiry in the Early Years (Julie Smart)

Teaching STEM Outdoors: Activities for Young Children (Patty Born Selly)