You, too, can design and implement math trails to promote active, meaningful, real-world mathematical learning beyond your classroom walls.
Do you know what my worst lesson is? It's math..., but I really like doing math when it's outdoors!

“My favorite bit this week was the math trail because it's outside and you get to do more things.”

These sentiments were expressed by nine-year-old children in Australia who had just completed a math trail as part of their school’s observation of mathematics week in March 2008. The week’s focus had been on using the outdoor environment to extend children’s mathematical awareness and learning.

A major component of children’s mathematical development is the ability to apply their learning to real-world contexts (NCTM 2000; Ofsted Report 2008). Outdoor environments provide endless opportunities for teaching and learning mathematics. Numerous math-rich examples, living and nonliving, can be found in the school playground, the shopping mall, the neighborhood park, the local gardening center, and the city museum, to name a few venues. Mathematical learning in such contexts is not enrichment; it is at the core of empowering children’s understanding of mathematics.

For several years, Steve Humble and Victoria E. Barnes have organized a number of math trails that have taken multiple groups of children—with their teachers, parents, and grandparents—out of classrooms and into the wider world. The authors share some of their trail explorations and suggest guidelines for designing and implementing trails of your own.

What are math trails?
Australian educator Dudley Blaine first developed the math trail concept as a way to promote active, meaningful mathematics learning beyond the classroom. A typical trail consists of a sequence of designated sites along a planned route where students stop to explore math in the environment (Cross 1997; Richardson 2004). Math trails make mathematics come alive for children by engaging them cognitively, physically, and emotionally.

Numerous math trail projects are conducted around the globe, many with dedicated Web
sites for problem sharing. For example, in the United States, a national math trail Web site invites students and teachers from any classroom in the world to post community-based mathematical problems that they have created. The problems are augmented with photographs, narratives, illustrations, video, audio clips, or any other graphic components that can be digitized.

The United Kingdom’s Department for Children, Schools, and Families hosts a Web site that incorporates math trails along with other rich activities. Leaders describe their Mathstastic project as “hands-on, minds-on, hearts-on.”

A joint effort
Students and teachers alike can create trails that target a range of mathematical understanding:

- **Student-created** for grade-level peers or younger peers to undertake
- **Teacher-created** for students to subsequently test and modify to produce new, improved versions
- **Teacher-created** for children and their families to explore in their school surroundings, their homes, or their local environments
- **Teacher-created** for teaching peers to test, improve, and implement

Additional math trail examples accompany the online version of this article at www.nctm.org/tcm. Go to the March 2010 online issue of *TCM* to read about the student-generated Easter trail, the teacher-designed Gateshead MetroCentre trail and the teacher-generated, student-improved Ouseburn trail. The following excerpt is from a student-generated math trail.

**Bamburgh Castle trail**
One of the most imposing edifices in England, Bamburgh Castle sits on a basalt crag along the picturesque Northumberland coast. The Bamburgh Castle math trail (see fig. 1) was the culmination of the work of several classes of students aged seven to eleven years. Before developing this trail, the children had created and worked many math trails, both inside and outside their school grounds. The children’s questions—including number, computation, measurement, space, and working with data—addressed a range of content.

**Getting started**
Introduce children to math trails by having them explore, in small groups, four or five areas of interest within their own classroom (e.g., the reading corner, the science project display). At
each area of interest, have groups respond to one or two questions such as these:

1. What are some ways that we could find out which books are the most popular in our class?
2. How might you rearrange the bookshelves so we can add more books?

Following several classroom explorations and follow-up class discussions, let children venture outside to experience a math trail, first in their school environment and then beyond.

**Trail creation**

Give some initial thought to a proposed outdoor math trail’s purpose and its anticipated learning. For example, if children are undertaking a unit on shape and pattern, then the math trail could focus on exploring various shape and pattern examples in the school buildings and on the grounds (e.g., “Be a shape detective.”). Alternatively, the math trail’s purpose could be to introduce students to various instances of outdoor mathematics that occur at scientific, historical, literary, engineering, or business sites. For instance, students could examine the structure of a nearby bridge, explore the brick or tile designs on a local historical building, or investigate science museum displays.

For a student-generated math trail, devote forty-five to sixty minutes to small-group exploration of places and objects of mathematical interest outside the classroom. As children
observe these areas of interest, have them develop questions that they would like their peers to answer (see fig. 2).

Back in the classroom, have groups share their questions with the entire class and decide which ones to use as a basis for their math trail problems. They should justify their selections with a focus on the mathematical appeal, diversity, and challenge of the questions and problems.

**Implementation**

Humble and Barnes normally present student-created trails in paper form, highlighting each site to be investigated with an accompanying photograph (e.g., of the corner store) and one to three problems to solve for each site. Students show their work and record their answers on question sheets, which are placed on clipboards.

Then the teachers usually allow ninety minutes to two hours for small groups to work the math trail. On average, the children spend five to ten minutes at each site, depending on the demands of the problems to be solved. Assigning a data crew to document the responses of each group at each site is a worthwhile component. A data crew comprises two to three children whose task is to collect pertinent data such as digital photographs, brief video recordings, and the groups’ written responses.

As students work the math trail, teachers can gain important insights into their mathematical understanding or lack thereof. For example, one teacher whose class went on a shape hunt quickly realized that her students did not fully understand the properties of a square. This observation became the focus of a follow-up classroom lesson.

Children’s math trail experiences can serve as transfer triggers. For instance, when students investigate symmetry in their classroom activities, remind them of the symmetrical...
To generate questions that they would like their peers to answer, give students about an hour for small-group exploration of a site and its objects.

Broadway Junior School math trail

1. How many railings does the big play yard have altogether?
2. If you start at the yard doors, how many footsteps does it take to get to the bottom of the yard?
3. What shape is the yard? Can you draw it?
4. Approximately how many meters is one length of the yard?

properties of the doors or windows in the old school building that they investigated on their math trail. You might even revisit the site.

Products
On your return to the classroom, give students opportunities to share their math trail discoveries and problem solutions. As the basis of a whole-class discussion on the math trail’s products, the data crew could initially report on what they collected and observed. The various documented accounts of the children's responses, including the data crew’s photographs and video records, are important when students share and assess products. Have students do the following:

• Compare problem solutions and how they were generated.
• Report any difficulties, challenges, and additional questions that arose in exploring each site.
• Share ways to improve the math trail.

When assessing children’s learning during and after a trail, teachers might consider these points:

• Different ways students solved the math trail problems
• Interactions with peers in solving the problems
• Conceptual strengths and limitations evident in responses and interactions
• Core content to target for further development in the classroom

Conclusions
A recent study in the United Kingdom (Ofsted Report 2008) provides strong evidence that well-organized activities outside the classroom contribute significantly to the quality and depth of children’s learning, including their personal, social, and emotional development. Outdoor math trails supply further evidence of such enhanced learning: They are meaningful, stimulating, challenging, and exciting for children. Most important, these trails invite all students, irrespective of their classroom achievement level, to participate successfully in the problem activities and gain a sense of pride in the mathematics they create. As youngsters discover real-world shapes, patterns, numbers, data, symmetry, and reflections—to name just a few examples—their eyes open to the mathematics in their world. They become math detectives—posing questions and solving problems as well as

More pi
This year, challenge your students to a refined recognition of Pi Day. On March 14, remember to recognize 1:59 p.m. as an accurate moment to honor this irrational number: 3/14 1:59. If someone has a second hand on his or her watch, you can be even more accurate: 3/14 1:59:26.
documenting and communicating their discoveries in multiple ways.

Teachers and parents value insights into children’s mathematical learning and different ways that this learning can be fostered in the home, the local community, and the school environment. Adults also appreciate seeing their youngsters totally immersed in learning. As one teacher said, “I’ve seen my children ready to ‘pop’ [because] they have been so excited about what they’ve discovered.”

Math trails empower lifelong learning. Integrating “outside” mathematics with “inside” classroom mathematics can sow the seeds to develop flexible, creative, future-oriented mathematical thinkers and problem solvers.

BIBLIOGRAPHY

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Sample questions

This example begins with basic How many? questions and extends to include more sophisticated, thought-provoking ones that involve describing, explaining, hypothesizing, justifying, and problem posing. You can easily tailor these sample questions to apply to a local math trail.

1. Look at that. Look around you. What can you see?
2. How many?
3. How far or near?
4. How long, short, tall, high, deep, heavy?
5. How many lines? How sharp? How curved?
6. How many objects in a line? How many in a shape?
7. How much do you see? How much more is hidden?
8. Can you find 5 of these…?
9. Estimate the size, height, length, weight of …
10. What is the name of…?
11. What kind of number?
12. What kind of pattern?
13. Can you continue this pattern?
15. Name some of the shapes you have found.
16. Did you find the…?
17. Why do you think lots of triangles have been used to…?
18. Why do you think the bridge is arched?
19. Why do you think the path does not follow a straight line?
20. What if we change this?
21. What if we add a line? What if we add a shape?
22. What difference does it make? Is it still symmetrical?
23. What if we double it?
24. What if we change the area?
25. What if we alter the symmetry?
26. Could you make a pattern with…?
27. Show that this works. Is it always true?
28. Imagine that …

Additional trail examples accompany the online version of this article in an appendix at www.nctm.org/tcm.


Additional math trail ideas

Easter math trail
A class of seven-year-olds—with some teacher support—created the Easter math trail (see fig. 3) for a parent-child activity day. Although the children posed questions that favored basic number, working the trail nevertheless involved substantial positional and spatial reasoning. The activity day gave parents an opportunity to observe their children’s mathematical learning and to appreciate that such learning does not take place within the classroom only. This endeavor was designed to promote future family journeys involving greater awareness of math in the community.

Ouseburn math trail
The Ouseburn math trail was initially created by teachers at a teacher education center in the United Kingdom. Their questions involved spatial patterns, spatial reasoning, measurement, number, and data collection and analysis. The teachers then presented the trail to four classes of nine- to eleven-year-olds, who worked for two one-hour workshop periods to improve the teacher-generated trail. They walked, in groups, through the trail’s various exploration points and reflected on the questions and problems the teachers had created.

Back in class, the children discussed and justified which questions and problems they considered the most appealing and worthwhile and then suggested changes (see fig. 4).

Gateshead MetroCentre math trail
Generated by Humble and a colleague, the math trail at Gateshead MetroCentre in the United Kingdom is in a large shopping center. (It can be explored year round by contacting the MetroCentre.) Measurement is among the many topic areas on this trail. Working with a metrounit, a motif that appears in repeating patterns throughout the MetroCentre’s balustrades, children make various length, width, and area estimates.

During two days in January 2008, approximately three hundred students and numerous parents per day explored the trail. Many of the children who participated usually exhibit social, emotional, or academic needs that require special attention in the classroom.

Feedback from the teachers, children, and their parents or guardians endorsed the success of this trail. All the children thoroughly enjoyed the day, describing it as “fun,” “exciting,” “interesting,” and “challenging.” At the same time, they recognized and identified the mathematics they had encountered:

“I could see squares, oblongs, and semi-circles.”
[My favorite part of the day was] “seeing lots of math in the MetroCentre—I never knew there was any.”

Parent involvement was a significant component of this success. Rather than divide a family, which mathematics can do at homework time, the mathematics on the trail brought families together. The children appreciated their parents joining them in working the problems on the math trail, something “they never do at home.” Other comments included enjoyment in “helping my mum with her math” and “showing my mum that there is more in the Metro than just shopping.” Students reported that they had to explain most of the mathematics to their parents or guardians—opportunities that provide students with valuable learning experiences.

Parental feedback indicated new awareness and appreciation of how adults can be involved in their children’s mathematical development:

“[This was a] great way to incorporate math into a shopping trip that will keep the kids interested and allow me to help them.”
“[It was] surprising that I can actually help my child with math—never thought I could.”
“[My favorite parts of the day were times] when the children were really thinking and being enthusiastic about the task,”
“[when I was] watching the excitement on the kids’ faces,” and
“[when I saw] children smile while learning math.”

Furthermore, parents expressed amazement at how easy it is to use the environment to teach and support children’s mathematical development. Fathers left with the intention of involving their children in weekend chores such as gardening, shopping, building, and renovating.
Seven-year-old students from the Broomhaugh Church of England First School generated this trail for a parent-child activity day.

Starting outside the school, carefully cross the road onto the pavement and walk to St. James’ Church. Stop at the gate outside the main entrance.

1. How many stone faces are watching you?
2. Look up at the weather vane. In which direction is the wind blowing?

Continue to walk along the pavement past the church. Turn left and follow the footpath over the bridge. Turn left past the tennis court to the play park.

3. How many swings are there in the play park?

Carefully cross Millfield Road; turn right and walk toward the main road. Stop at the Millfield Road sign. Turn left and walk carefully to Sandy Bank.

4. What is the date on the wall of Bobby’s Shop?

Continue to walk up Sandy Bank.

5. Count the number of gates on the way up to the top of the hill.

Cross over onto the pavement on the right-hand side and walk until you reach the first road on the left. Take this turn and continue until you reach the footpath on your left. Take the footpath down the hill. Halfway down the hill is a split fence.

6. How many pieces of wood does it take to make this split fence?

Carefully cross over the road at the bottom; follow the yellow arrow toward the wooden bridge.

7. Count the steps out loud as you walk down. How many steps are there?

Follow the footpath to the left of the bridge and back onto Marchburn Lane. Turn right.

8. Circle the shapes below that you see in the railings over the bridge.
Nine- to eleven-year-old children discussed and justified which teacher-created questions and problems they considered the most appealing and worthwhile for the Ouseburn math trail.

**Ouseburn math trail**

*Stand outside Ouseburn Farm. Look at the gates to the farm grounds.*
1. In the box to the right, draw the leaf motif you see on the gates.
2. Talk together about any patterns you can find in the artist’s design.
3. Find two **concentric circles** built into the ground nearby.
4. In pairs, talk about how you could measure each circle’s circumference.
5. Find the circumference of each circle.
6. What is the difference between them?

*Look at the Ouseburn Farm window.*
7. How many circles can you see?
8. Go inside to see what it looks like from the other side!

**Halfway up the entrance ramp, find the yellow ADT alarm on the wall.***
9. Count the sides.
10. Name the shape.
11. In the box to the right, draw a repeating pattern you can make with this shape.

**Walk back down to the wooden bridge over the river. Cross Foundry Lane and walk up the steps to your left, which lead to the Cumberland Arms.***
12. Count the steps as you go, looking for a pattern made by the step sizes.
13. Can you make a musical pattern with your voices as you go up, to fit with the pattern of small and large steps?

**Find the storytelling circle on your left at the top of the steps.***
14. How many children can fit on to the seat pictured?
15. How long would the seat have to be to fit twelve children on it?

**Walk up the steps to the pub terrace and stand at the railings.***
16. Look across to Byker Bridge and spot a church with a pointed spire.
17. You should be able to see the tops of buses and lorries crossing the bridge.

**Work for 5 minutes to complete the tally chart below.**

<table>
<thead>
<tr>
<th>Start Time</th>
<th>Traffic toward City Center</th>
<th>Traffic away from City Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td><img src="image" alt="Bus" /></td>
<td></td>
</tr>
<tr>
<td>Lorry or van</td>
<td><img src="image" alt="Lorry" /></td>
<td></td>
</tr>
</tbody>
</table>

18. After finishing your tally, talk about what you have found (e.g., Is there more traffic going toward the city or away from it? Are there more buses or more vans and lorries going over the bridge?)

**Walk back down the steps to the river and back to Ouseburn Farm.***