

"NOW I SEE WHY YOU MADE US LEARN THAT STUFF!"
--THE REWARD OF OUTDOOR MATHEMATICS

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A chambered nautilus . . . Kaleidoscopes . . . a sunflower . . . compass bearings . . . an acre . . . a transit . . . a sand dollar . . . stream velocity . . . a clinometer. For students enrolled in mathematics courses at Fairmont High School in Kettering, Ohio, these seemingly unrelated items serve as evidence that mathematics, nature, and learning are interrelated in some magical ways.

Probably each of us math teachers has heard, "Why do I hafta learn this stuff?!", and each of us has offered some feeble response in an attempt to justify the learning of some mathematical concept. I have found that the direct application of math concepts in an outdoor setting can serve as a powerful motivation for learning. It has indeed been a thrill for me to hear students remark, "Now I see a use for all that stuff." Now I hear them actually admit to having fun while applying mathematics. This is a real treat and motivation for the teacher.

Recently I received a letter from Dave Pritchard, a former student, in which he referred to his experience years ago as a participant at a weekend outing called the Math Retreat. (An article about this program first appeared in the Ohio Council of Teachers of Mathematics Journal of Mathematics in February 1981).¹ Pritchard stated:

The most valuable thing that a student can take from the classroom is a genuine appreciation for the subject. The relevance and practicality that (my attendance at the Math Retreat) gave to the subject made me appreciate mathematics. I enjoyed learning orienteering skills on the Outdoor Math Retreat, as well as using trigonometry to determine the height of a barn. Observing the spiraling in a chambered nautilus shell recently made me recall our discussions on geometry in nature.

Realizing that this experience obviously had a great impact on this young man, I decided that it was time to update the article and share with other teachers the news of a successful way to

leave students with a warm afterglow feeling about mathematics. It is hoped that with the suggestions presented through this article, each reader can tap his own personal resources, let the imagination go, and help students explore the world of mathemagic that exists outside the classroom. As the 1947 National Council of Teachers of Mathematics Yearbook states: ". . . for one simple problem in surveying will teach more geometry than a whole set of textbook problems."² I think that Dave Pritchard's comments certainly attest to that!

Outdoor Math Retreat

Since 1978, students and teachers at Fairmont High School have had a chance to discover the abundance of mathematics in a natural setting through participation in an outdoor "Math Retreat." This popular weekend field trip is conducted each October at the Glen Helen Outdoor Education Center, an outstanding school camp facility near Yellow Springs, Ohio. Coordinated by math teachers Dianne Olix and Bill Kramer, the Math Retreat program has attracted quality leadership from many teachers and adult leaders from Kettering and neighboring school districts. In fact, often a former participant will volunteer to return to Glen Helen as a Retreat leader. This is certainly testimony to the good feeling students can gain about mathematics through a program like this.

Objectives

The Math Retreat attempts to satisfy the student needs in three learning domains: cognitive, affective, and psychomotor. The primary objective is to provide opportunities for math students to experience applications of math skills and concepts. A secondary intent of the Retreat is to offer opportunities for student interaction and personal growth through work with groups. Finally, the Retreat is designed to stimulate an appreciation of the outdoor classroom environment through vigorous physical activity.

Preparation

About 35 to 40 students sign up for the Math Retreat each year. Any student who has completed Algebra I is eligible to attend. An orientation session for participants is conducted at

school the weekend prior to the Retreat. During this session, students learn how to use a magnetic compass to complete a short orienteering course. They also practice using a transit and a clinometer. In addition, the various activity sessions of the weekend Retreat are explained, and the participants select their preferred activities. (See Math Lab Sessions.) During the coming week, leaders make final preparations in planning meals, preparing materials, and scheduling activities.

Beginning the Weekend

Early Saturday morning students and leaders gather at school for the bus trip to the Outdoor Education Center. A Glen Helen staff naturalist will meet the group to explain the camp's guidelines. The students then have a brief tour of the lodge and cabins and review a map of nearby trails.

Some time was spent at the school orientation session the weekend prior to the Retreat in familiarizing the participants with use of some measurement devices, but once the students are "on site" at Glen Helen, the emphasis is on working together closely with new and previously-learned skills. In order to promote a spirit of cooperation, an opening event of the weekend is a game to learn everyone's name. This is followed by a series of obstacle courses to be tackled in groups. These obstacles are posed as simulations requiring climbing a "great wall," crossing over a "river," and sending a message over a "telephone pole." The students will then venture out on a "Mystery Number Hike" to learn about the history, biology, and geology of the Yellow Springs area. The first mathematics of the weekend is slipped in following this hike by having the students complete a short multiple-choice quiz about the spots visited. The answers are coded to numbers--some positive and some negative--and if the sum of the answers totals correctly, the "mystery number" has been found.

Math Lab Sessions

The primary objective of the Math Retreat is achieved by offering the student participants a chance to apply math skills and concepts through a series of problem-solving "math lab

sessions." For these labs, students work in small groups of 6-10 with a teacher or a student leader who attended the Math Retreat the previous year. The leader will pose a problem and offer some suggestions that may lead the team to the discovery of a solution.

The majority of time Saturday afternoon and Sunday morning is spent in a rotation of math lab sessions. Generally, four sessions are being conducted simultaneously at different locations. Each participant receives a personal packet of materials, which includes a rotation schedule and a map to find the lab locations. Each student's name tag is marked with a color, a number, and a geometric shape, and some of the required lab assignments are made by grouping through those name tag categories. Other times, the students have selected their preferred optional labs in advance. Participants are thus constantly intermixed throughout the weekend and really get to know each other and their leaders.

Measurement Labs

Some of the math lab sessions involve use of measurement, others feature computation and logic, and some blend mathematics, art, and nature. One required math lab session challenges the students to determine the height of a barn through four different methods of indirect measurement. Tools to be used include a pencil, a mirror, a clinometer, body measures, and a transit. For another session, students must enclose an acre with rope, then estimate the number of acres contained within a field. The only clues provided are the square foot area of an acre and a 2-foot-long piece of rope. Once the size of an acre has been realized, questions dealing with large numbers are posed--such as, "If you could spend \$1,000 a day, how long would it take to spend a billion dollars?"

A third measurement lab finds the students drawing a map of a trail, using only a magnetic compass, a tape measure, and graph paper as aids. At another location, students conduct measures to determine the speed of the water flowing in a stream, the circumference and diameter of a tree trunk, and the volume of water that would fill the space below semi-circular arches of a bridge. In

all the measurement labs, estimation is attempted first. Students are then encouraged to use a variety of measurement tools and explore several ways to determine solutions.

Compass and Transit

The use of a magnetic compass is practiced through a lab which requires students to follow a one-mile orienteering course laid out through the woods and trails of Glen Helen. Students must orient their bodies to directional bearings and then pace distances according to instructions on "station markers" which are posted on rocks and trees along the course. Skill in the use of a compass must be learned well on Saturday, since Sunday afternoon the highlight is a 26-station three-mile orienteering hike. (See Hike.)

For the student interested in surveying techniques using a transit, one lab determines the amount of elevation gain along a roadway, and another challenges the students to determine points of equal elevation and then work with a topographical map of contour intervals. In another situation, no compass, protractor, or transit is permitted as students attempt to use only a tape measure to determine the inaccessible straight-line distance between two trees on opposite sides of a building.

Logic and Art

Additional labs feature the challenge of solving some logic puzzles and some paper-and-pencil brain teasers. Students can also attend a lab to explore some number theory and learn a new way to determine a square root. For the artistically-inclined youngsters, one lab explores the geometric principles of kaleidoscopes by examining cut-away models. Students then build a simple kaleidoscope using mirrors and finally use a simple kit to build a closed cardboard tube kaleidoscope. Many students especially enjoy a lab in which they build designs using string art patterns, either nailed onto boards or woven into cardboard sheets. A final example of blending art and form with mathematics is demonstrated in a lab in which students build models of geometric polyhedra, such as a dodecahedron.

Treasure Boxes

One of the more intriguing lab sessions features a collection of "Treasure Boxes." This is analogous to a mathematical treasure hunt, in which students discover some of the fascinating ways that Mother Nature demonstrates the wonders of mathematics. Each box features an item of nature along with a card that describes the mathematical relationships to be observed. The Treasure Boxes include such things as sea shells, pinecones, starfish, seed pods, flowers, butterflies, beehives, and crystals. Many students are truly enthralled by the beauty of mathematics as revealed through this treasure hunt.

Survival

A final required lab has very little mathematics involved, other than a healthy dose of logical reasoning. This is a "survival simulation" in which student teams pretend they have been in a plane crash and must successfully perform a series of tasks in order to survive. Following a leader's discussion of survival skills, each team is given a box containing 15 items. Within five minutes they must select six of these items deemed most necessary for survival. They are then given a series of tasks to be completed in five minute intervals. The give-and-take discussions of this lab are amazing, and the teamwork aspect is really fun to observe. Unfortunately, not all teams work together well enough to "survive," but they have a good time discussing this event the rest of the weekend!

Other Activities

Although application of mathematics is the primary goal of the Math Retreat, the opportunity for social interaction and personal growth is also important. In addition to the students' mingling through their lab assignments, they also are mixed in with one of ten work crews, such as "pizza cooks" or "lodge cleaners." The students generally pitch in and do a nice job, and many of them gain some new friendships through their work assignment. Sometimes they even admit to having fun while working at these chores!

Although the scheduled labs and duties keep the students quite busy, they do have some free time built in. Meal times are planned to be a highlight of the weekend, and the excellent food always receives rave reviews. Often a surprise birthday party is held. Prior to meals, many of the students enjoy activities such as playing board games, hiking to scenic spots, playing football, visiting the bird blind, and playing the ever-popular game of "spoons."

As a by-product of the intellectual and social learning promoted by the Math Retreat, it is hoped that the participants will gain an awareness of the need to preserve and enjoy our outdoor environment. To this end, the staff naturalists of the Outdoor Education Center give a presentation with a live owl Saturday evening. They also lead small groups into the Glen on a very popular "night hike," conducted after dark--without flashlights. The night hike turns out to be a very peaceful, thought-provoking experience for most of the participants. Following the hike, the showing of the Disney movie "Donald Duck in Mathmagic Land," provides reinforcement for the relationships observed in the Treasure Boxes--and a welcome cider and doughnut snack! To close out the evening, everyone can gather around the campfire for a traditional sing-a-long and marshmallow roast.

The Hike

The final event of the weekend is a three-mile orienteering course which is laid out on the grounds of Glen Helen Sunday afternoon. Following an instruction session, students working in teams of three or four depart every 15 minutes on this challenging hike. Directions are posted on rocks or trees at checkpoints spread along two separate courses. One course is fairly easy, staying primarily along established trails and visiting several historical sites throughout Glen Helen. Participants who select this option can enjoy a leisurely hike through some beautiful spots in the Glen. The other course is more challenging, diverting from the trail frequently and giving the students a chance to really test their skills. Although hikers may encounter massive numbers of stick-tights while bearing through deep brush, some-

times they will be lucky enough to startle wild animals while following this course. On either course, careful use of compass bearings and step pacing are imperative, since snacks are served at the final destination, and lost teams must go hungry. So far not a single hiker has been left lost in the woods--the motivation to reach that snack must be tremendous!

Conclusion

The close of the Math Retreat weekend generally results in a lot of tired bodies, yet both the student and adult participants talk about this event for weeks to come. It seems that the temporary physical exhaustion is a small price to pay for the lifelong mental spark that is stimulated by this program. Perhaps the best measure of the success of the Math Retreat program is the favorable response from the student participants who evaluate the weekend. Typical comments include: "I learned a lot and still had fun at the same time" . . . "I had a great time and will always remember this as a good experience" . . . "I learned some great things about math, nature, and best, other people" . . . "Now I know why da Vinci said that 'Mathematics is God's alphabet in creating all things in Nature'." Although this last comment is a slight misquote, it is indeed apparent that the student "mathletes" truly gain a new appreciation for the wonders of mathematics through their participation in the Math Retreat.

REFERENCES

1. Ohio Journal of School Mathematics, Vol. 4, No. 1, February 1981.
2. Surveying Instruments--Their History and Classroom Use, National Council of Teachers of Mathematics Yearbook, 1947.