

AC 2007-2566: EXPLORING MATH THROUGH MATH COMPETITIONS AT THE ELEMENTARY SCHOOL LEVEL: CASE STUDY OF A K-12 APPROACH

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Exploring Math through Math Competitions at the Elementary School Level: Case Study of a K-12 Outreach

Abstract

Studies have shown that engineering enrollments nationwide are declining or flat and US students lag in math behind other developed countries. Leading educators have challenged engineering educators to intervene at an early stage to improve math education. This paper is a case study of a decade old, volunteer-run, before-school “math club” enrichment activity at an elementary public school in Washington State for fourth through sixth graders. Math is promoted among students by preparing them to participate in various math competitions at the local, state, national and international level. The process of establishing the club, development of a work schedule, various math competitions available to Washington State elementary school students and their levels of difficulty, and challenges, rewards and lessons learned through the past seven years are described. By getting involved in such programs engineers have an opportunity to teach students the art of problem solving along with team building, leadership and negotiating skills, keeping schedules and meeting deadlines which are important skills for an engineering career. This is also a great opportunity to build a positive image of engineers among K-12 students and to attract girls to engineering.

Introduction

The Trends in International Mathematics and Science Study carried out in 2003 assessed about half a million students after fourth and eighth grades from about 45 countries around the world. It showed that although US eighth graders achieved a higher score in mathematics than the international average, they were outperformed by more than ten other countries¹. According to the Washington Assessment of Student Learning (WASL) only 49% of the eighth graders in Washington State met the required standard in math in 2005-2006². Statistics also show that freshmen enrollment in engineering is slowly declining since 2002^{3,4}. Leading educators have challenged engineering educators to intervene at an early age to improve math education in primary and secondary schools⁵.

If we are interested in improving math education we should start at the elementary school level, similar to starting music and sports for children at a young age. This paper is a case study of an entirely volunteer run, before school, enrichment “math club” in an elementary school in Shoreline, Washington. Similar to learning a sport during practice sessions and competing in inter-league games during the season, the purpose of this math club is to coach the students in math during the early part of the academic year and then let them participate in various math competitions in the second half of the year. The paper describes the history of establishing the club, development of a schedule for the math club, and some of

the soft skills learned by students. It also provides information on various competitions that are available to students in Washington State and ranks them according to the level of difficulty. Finally it discusses the lessons learned in the past seven years which may be helpful to those who are considering starting one in their own neighborhoods.

MathClub - Inception through Current Status

The math club was started in mid 1990's with one parent volunteer and a few students. It was a before school 50-minute, unstructured, enrichment program, where students from 2nd through 4th graders came in to play math related games and puzzles. Each session typically had about 20 students. However, after a few months the organizer realized that attendance was a serious problem. Parents brought their children in when they felt like it and there was no dedication towards the club. The parent volunteer decided to infuse some competitive spirit to the club to improve morale.

So the next year, the math club moved from a drop-in session to a semi-structured math skill learning session. A couple of simple contests were selected and the students were coached to take part in them. The coordinator contacted a few parents asking whether their children would be interested in joining the club and the rest of the students came through word of mouth from friends. It had about five students to begin with. The club increased to a dozen in a few months; the students had varying skill levels. With increasing number and varying skill levels, the coordinator needed more parent volunteers, some to lead sessions and some to serve as coaches' aides. The coaches' aides roamed around the classroom and helped the students with problem solving. To make parent volunteers' time worthwhile, a weekly schedule was developed. The content of the schedule itself will be discussed later, but the schedule enabled parent volunteers to know ahead of time what topic was being covered each week. As the word got out about the math club, more parents wanted their children enrolled. To meet the demand, more sessions were opened and each session had a maximum of about 12 students to provide individual attention to each student. Almost a decade after inception, the math club now has close to 60 dedicated students and has five parent coaches leading different sessions.

Math club starts in early fall quarter at the beginning of the school year. Announcements about the math club are made at end of summer school open-house, school social events and in several issues of the school newsletters. Over the years, the club has built a reputation so that there is a good turnout starting the first day. Students are divided into different sessions not simply based on their grade level but also based on the previous year's performance in the math club. Students who are new to the math club are assigned to a beginners group and moved up as appropriate. Every attempt is made to avoid a situation where a student is placed in a higher level group and then moved down.

Pre-Competition Preparation

The aim of this club is to prepare students for various math competitions. Therefore in the early stages one of the coaches (the author) researched various math competitions, contest formats, topics covered and type of questions appearing in each contest. Most contests covered three major areas, namely, number sense and algebra, geometry and measurements, and probability and statistics. In addition, some contests covered mental-math, where an adult reads a question and the student works it out without any writing tools. Also, some contests required students to work fast. So the students also needed to develop speed in problem solving for certain contests.

Based on the findings of the above research, the author developed a weekly lesson plan covering various contest topics, sample problems to work in class and assigned contest problems as homework. An example schedule for the first year math club students (typically fourth graders) is shown in Table 1. These topics covered in a student's first year of math club are reinforced every year with additional topics and skills introduced in subsequent years till they complete elementary school in 6th grade. Some of these additional topics being, percentages, speed-time relationships, interpreting graphical data, areas and volumes of various geometric shapes, Pythagoras' theorem, symmetry and pattern recognition, and probability of independent and dependent events.

Table 1. Sample Schedule for Beginning Mathletes

Lesson No.	Major Area: Topic Covered
1	Number sense: Rules of divisibility by 2, 3, 4, 5, 6, 7, 8, 9, 11
2	Measurements: Area and Perimeter of Rectangles
3	Algebra: Arithmetic Series, patterns, term identification
4	Algebra: Problems with single unknowns
5	Number Sense: Fractions
6	Probability and Statistics: Mean, Median, Mode
7	Geometry: Triangles: types, angles
8	Geometry: Circles: area, perimeter
9	Probability and Statistics: Probability of independent events
10	Measurements: Conversions (ton-lbs-oz; mile-yard-ft-in; SI units)
11	Probability and Statistics: Simple Permutations and Combinations

The usual format for the math club is 20 minutes of instruction introducing a concept followed by 20-30 minutes of problem solving. During the problem solving session, students are encouraged to share their approach with the class.

This helps them to develop communication skills as well as to see how a problem is approached by different individuals in different ways.

Competitions

November through May students participate in various local, regional, state, national, and international competitions. Competitions that the students take part in, the grade levels, information on whether they are local, state, national or international competitions and the contest websites are tabulated in Table 2. For this paper, the level of difficulty, based on student performance and feedback, is ranked on a scale of 1 to 3 - 1 being basic, 2 being moderate and 3 being challenging. Some contests have past or sample tests posted on their respective websites. Some past contests can be purchased for a fee. The contests from past few years are made available to the students and usually are assigned as homework.

Table 3 summarizes the format for each contest. Contests fall under three categories:

- team only events (WSMC)
- individual tests only (AMC 8, MOEMS)
- team and individual events (Washington State Math Championship, Shoreline Math Olympiad, MATHCOUNTS, Math is Cool)

In addition to the information provided in Tables 2 and 3, some other useful information on each contest is summarized below.

Shoreline Math Olympiad

- Because the purpose of this contest is to promote math at the local level, problems are kept simple and plenty of awards are given out. Schools with the most number of participants are also recognized.

Washington State Math Council's Math Olympiad (WSMC)

- This is a statewide contest held on the same day in about 20 sites around Washington State.
- Because all tests are team based, this contest is ideal for students who feel intimidated by individual contests.
- Teams don't compete against each other; every team that scores at a pre-determined level wins a prize.
- The hour-long open ended problem makes students think outside the box. Several engineering related problems have been incorporated in the past (e.g. Designing a wooden deck around a swimming pool with given material constraints).

Washington State Math Championship

- This is a highly prestigious contest in Washington State.
- Students need to develop strong analytical skills and speed in problem solving.

Table 2. Information on Math Contests in which Students Participated

Competition	Local/Regional/State/ National/International	Grade Level	Level of difficulty (1 to 3)	Website (if available)
Shoreline Math Olympiad ⁶	Local	4 to 8	1	http://www.shorelineschools.org/instruction/ (limited information)
Washington State Math Council's Middle School Math Olympiad (WSMC) ⁷	State	5 ^a to 8	1	http://www.wsmc.net/
Washington State Math Championship (WSM Championship) ⁸	State	5 ^a to 8	3	http://www.blaine.wednet.edu/
Math is Cool ⁹	Local, Regional, through State	4 ^a to 6	2	http://www.academiccarecool.com/index.php
MATHCOUNTS ¹⁰	School, Chapter, State through National	6 to 8	3	http://www.mathcounts.org/
Math Olympiad for Elementary and Middle Schools (MOEMS) ¹¹	International	to 8	2	http://www.moems.org/
American Mathematics Competitions - AMC ⁸ ¹²	International	8 ^a	3	http://www.unl.edu/amc/

^a students from lower grade levels can participate

Table 3. Contest Formats

Competition	Format
Shoreline Math Olympiad	<ul style="list-style-type: none"> • Two, 20-minute, 15-question multiple choice individual tests • Two, 20-minute, 8-question team tests
Washington State Math Council's Middle School Math Olympiad	<ul style="list-style-type: none"> • One hour-long, open ended question, team test • Five, 15-minute team tests
Washington State Math Championship	<ul style="list-style-type: none"> • Five, 15-minute team tests • One, 45-minute, 30-question, individual test
Math is Cool	<ul style="list-style-type: none"> • One, 35-minute, 40-question, individual test • Five team tests ranging from traditional to non-traditional test formats
MATHCOUNTS	<ul style="list-style-type: none"> • One, 40-minute, 30-question, individual test • Four pairs of questions, 6 minutes/pair, individual test • One, 20 minute, 10-question, team test
Math Olympiad for Elementary and Middle Schools (MOEMS)	<ul style="list-style-type: none"> • A monthly contest from November through March; 5 problems per test; typically 20-25 minutes/test; individual test.
American Mathematics Competitions - AMC 8	<ul style="list-style-type: none"> • One 40-minute 25-question, individual test

Math is Cool

- This the most fun competition for students.
- Team contests involve relay style and college bowl competitions.

MATHCOUNTS

- This highly prestigious contest, sponsored by National Society of Professional Engineers, could lead to national competition.
- The contest is primarily for 7th and 8th graders. However, 6th graders can participate.

MOEMS

- This contest is held within the school which makes it convenient.
- Third through sixth graders do the same test and the contest is open to students around the world. However, the level of expectation should be clearly defined to the students. Usually, 3rd and 4th graders may get only 1 or 2 problems (out of 5 questions) correct. Fifth graders may get 3 to 4 problems correct. Sixth graders get 4 to 5 problems correct. This contest shows the contestants how their math skills develop over the years.
- At the end of the contest, statistics is available by grade level and state. This helps the parents to assess how their child compares to other students by grade and by geographic location.

AMC 8

- This contest is held within the school which makes it convenient.
- This is an 8th grade test that the author strongly encourages the 6th graders to participate. The 5th graders are informed of this contest and several 5th graders have participated in it and done well.
- At the end of the contest, statistics is available by grade level and state. This helps the parents to assess how their child compares to other students by grade and by geographic location.
- Like for MOEMS, student performance expectation should be clearly defined for different grade levels based on previous years' statistics.

Lessons learned

The author has learned several lessons from the past seven years of involvement in the math club. These may be useful for those who are interested in starting such an enrichment program in their local schools.

Develop a schedule or lesson plan for the entire school year. A lesson plan helps parent volunteers to serve as mathclub aides during the sessions. These volunteers roam around and help students who need some additional help. The schedule also helps all session leaders to work in a seamless manner as students move from one group to another.

Try to maintain a manageable number of students for each session. Ten to 12 students per session works very well. This provides an opportunity for the coach to know each student's personality and potential.

Try to optimize a coaches' ability. Some coaches are very good at working with and motivating students at a young age. Some coaches enjoy and do a terrific job coaching students for highly competitive contests. Each parent volunteer needs to find his/her niche. Also, working with different coaches students are exposed to different methods of problem solving.

Assign and emphasize the importance homework. Students are required to do at least two hours of homework per week. The author emphasizes the fact that children who learn a musical instrument are required to practice their instrument daily or at least several times a week. The same rule should be applied to mastering math. Kumon, one of the most effective math instructional systems, is based on daily practice of math principles learned.

Reward students for participating in the math club. In sports we reward every child for their ability to play a game, participation, and sportsmanship. Similarly, organize an award ceremony at the end of the math club season to recognize winners of various contests. You could also reward students who are most improved, most enthusiastic, did most homework, attended most about math and to encourage learning.

Recruit a dedicated parent who is not a coach to serve as the contest coordinator. Coordination for the contests involves informing parents of contests, collecting contest registration fees, registering teams, and arranging carpools on the day of the contest. Communicating with parents is usually the hardest due to everyone's busy schedules.

Engineers should get involved in test writing committees. Many of these contest planning committees need individuals who can write tests. Engineers can introduce interesting engineering related problems at an early age to students.

Other Benefits

In addition to learning analytical and problem solving skills, math club provides an ideal environment for the students to develop the ability to work in teams, practice leadership, negotiation and time management skills. These are useful skills for students to develop irrespective of their future profession.

The author requires that during team contests, each problem be solved by two students independently and the results compared and discussed. This builds a student's ability to explain their approach to another, and to learn from each other as a team. Also, each team selects a leader for a contest. The team leader keeps the team focused during the contest, compiles the answers at the end on the official answer sheet, and decides on the final answer if there is disagreement among team members. Students learn to manage their time during the year keeping a weekly schedule to complete their homework. When practicing for and participating in contests they learn to work under time constraints.

The author found it to be a great opportunity to talk to students and sometimes to the parent about engineering in an informal setting during problem solving sessions and at contest events. It was most rewarding when some of the female students wanted to consider engineering as a career choice due to positive role model influence by the author.

Conclusions

A completely volunteer run, math club was established in a Washington State elementary school a decade ago. The aim of the club was to encourage students to learn math by preparing them for several local through international math competitions. Sample math club schedule and description of math contests available to Washington state students are presented. Students develop analytical and problem solving skills along with team building, leadership and time management skills through participation in the math club. It is hoped that the information shared and lessons learned from past seven years of the author's experience will help those who are interested in starting a similar activity in their geographic region.

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