Recruiting Students in Computer Science and Mathematics through High School Programming and Mathematics Contests

Curt Jones, Lisa Lister, John Polhill
Bloomsburg University of Pennsylvania
Department of Mathematics, Computer Science, and Statistics
Bloomsburg, PA 17815
cjones@bloomu.edu, llister@bloomu.edu, jpolhill@bloomu.edu

There has been a recent nationwide attempt to attract students to the study of mathematics and computer science. In particular, the official goal at Bloomsburg University is to achieve a 5% increase in the number of students in these majors. Toward this end the Mathematics, Computer Science, and Statistics Department has implemented a variety of initiatives that are discussed in "One School's Success in Recruiting Mathematics and Computer Science Majors" in the May/June 2003 issue of the Mathematical Association of America's *Focus*.

At the 2003 ICTCM in Chicago, we gave a talk based on this article. The majority of the discussion during this presentation involved only one aspect of our recruitment efforts, namely our high school contests. This article will focus on these contests.

Reasons for Having Contests

Bloomsburg University is a rural four-year state college in Northeastern Pennsylvania, with approximately 7500 students. Nearly all of our students come from Pennsylvania, New York, and New Jersey, with 90 percent from Pennsylvania. Due to this fact, it makes sense to have outreach programs such as the competitions for area high school students. We hope to attract some of the contestants to study at Bloomsburg. Moreover, the team advisors see that our professors enjoy teaching mathematics and computer science, and students at Bloomsburg University can interact closely with the faculty. We expect that advisors will see Bloomsburg in a positive light and might recommend it to their college-bound students. Both our contests have also been featured in newspaper articles and have had regional television coverage, which is another way for students considering computer science and mathematics majors to recognize our university.

Beyond recruitment, as teachers of computer science and mathematics, we feel that we have a certain responsibility to make sure that good students pursue these disciplines whether at Bloomsburg University or elsewhere. The contests allow students to get excited about these subjects and the enthusiasm of the teachers and participants is much like that of a sports competition. Once students see that math and computer science can be interesting and fun, it is our hope that more of them will consider these majors when thinking of their futures.

Programming Contest

Members of our student chapter of the Association for Computing Machinery (ACM) suggested a high school programming contest as a method of introducing Bloomsburg University to prospective students. To make the University appealing to these students, we need to ensure that the contest is well organized and participants enjoy the event.

Our contest entails three hours of programming by teams of four students. Schools are allowed to bring multiple teams and each is allowed two computers and one printer. The students can program a problem in any language of their choice. Since each school brings their own equipment, the students do not need to worry about learning how to use our systems. Our contest runs from 9:00 AM to 12:00 PM followed by lunch from 12:00 to 1:00 and our awards ceremony from 1:00 to 1:30. Students are thereby able to return to their own high schools in a timely fashion.

We provide eight to ten programming problems of increasing degrees of difficulty for the teams to complete. We start out with two simple problems that the top schools will solve in ten minutes and all schools will eventually solve during the contest. A sample problem here would involve calculating the total cost of a group of items along with the sales tax amount that would be charged on the sale. We gradually increase the degree of difficulty until we have a problem with a solution that requires using an array or other linear data structure. Since we are part of the Mathematics Department, many of our problems involve this subject. We usually have two problems that require a great deal of thought, but our contest is designed for multiple teams to solve the entire set of problems. The winner is the team who solves all of our problems first. Usually eight to twelve of our 50 teams will solve all the problems, while all teams will solve at least two to four problems. We have listed some sample problems from previous contests as an appendix.

Department professors write the contest problems. University students and faculty both serve as judges during the contest and the Provost presents our awards. We found that our students and faculty enjoy the contest as much as the contestants do.

Mathematics Contest

Since the Programming Contest had been such a success, our Department and Math Club decided to introduce a Math Contest in the fall of 1998. This daylong competition began with 60 students from 10 area high schools and has grown to include nearly 200 participants. Students compete in teams of four, with at most four teams from any one school.

The Math Contest consists of three parts: the Quiz Bowl, the "Game of 24 Points", and Brainteasers. The Quiz Bowl and Brainteaser competitions take place in the morning and after lunch students compete in the "Game of 24 Points". The Quiz Bowl is a fast paced Jeopardy type game in which teams compete in pairs. Due to time constraints, the top 16 scoring teams continue on to the second round. In all subsequent rounds, the winners

advance. Not wanting the contest to be restricted to juniors and seniors only, the questions for this competition come from algebra, trigonometry, geometry, basic probability, and logic. No questions come from calculus. Students are given one minute to answer the questions, with the first team responding correctly getting the point. If a team answers incorrectly, the other team is given an additional 30 seconds to try to answer the question. Each round of this competition gets progressively more difficult. A typical question in the first round would be:

> Find the line parallel to $y = 6$ containing (3, -2).

A characteristic question for round four or five would be:

> A charitable society has enough money to feed the residents of an institution for a certain number of days. If 40 of the residents are transferred to another city the money will last 40 days longer. If 80 additional residents are admitted to the institution, the money will last 20 days less. How many residents does the institution have?

To keep students busy while they are not competing in the Quiz Bowl they have been given Brainteasers. The Brainteaser is a written exam consisting of 25 to 35 weighted problems that are logic and math puzzlers. Sample questions for this contest are:

> What is the least natural number that is evenly divisible by all of the digits 1 - 9?
> What is the last digit of the number 8^{2003}?

We select problems from a variety of sources including books of math puzzlers and faculty research projects. Teams compete in groups of four without a calculator, and questions are graded as either right or wrong, with the highest score winning.

The "Game of 24 Points" is a card game that uses a standard deck with face cards removed; the remaining cards give the numbers one (Ace) to ten. Four cards are dealt and using addition, subtraction, division, and multiplication, students try to obtain a specified number. For example, if they are trying to obtain 24 and are dealt a 3, 5, 7, and 9, they could say $5 \times 9 - 3 \times 7$. The number needed is usually 24, but we have found that when the game is played often enough, players memorize patterns of cards. To make it more difficult, we change the number they are trying to obtain during each round of the competition. Any number from 22 to 27 has a high probability of being obtained from four randomly dealt cards. This competition is run similarly to the Quiz Bowl, with the top 16 scoring teams advancing to the second round and winners advancing in all subsequent rounds.

Fees and Prizes

For both contests, each team pays an entrance fee of $40 to $50. These fees together with funds allocated by the Department and the University allow us to provide each student

with a T-shirt, lunch, and certificate of participation. We also provide a T-shirt and lunch for the team advisors. The members of the top team in the Quiz Bowl and the top team in the Programming Contest are given scholarships to the University. In the Programming Contest, the top six teams receive a plaque and the top six schools receive prizes ranging from digital cameras to computers. In the Math Contest the top three teams in each competition receive a plague and the members receive a prize such as the student version of Mathematica or gift certificates to Barnes and Noble. It is important to note that neither contest would be possible without the student and faculty volunteers.

Student and Faculty Volunteers

An added benefit of our competitions is that we have a considerable number of volunteers both from the faculty and from the student body. Students have the opportunity to work closely with their professors, and everyone gets a break from their usual routine. The contest simply could not be run without the help of the students. Tasks performed by the students include: generating problems, editing the problems, keeping time and checking answers during the Quiz Bowl rounds, checking programs for accuracy, and many more. For each contest, we may have as many as ten different faculty members volunteering their time to help when necessary. These competitions genuinely bring the department together.

Conclusion

We have truly enjoyed running our contests over the past few years and may consider adding a third contest in years to come. We are aware that other colleges and universities have such competitions, and perhaps by offering these contests we will be able to attract more students to the disciplines of mathematics and computer science. We should mention that the number of majors in our Department has nearly doubled over the past six years, and we think this is due in large part to the success of our contests.

APPENDIX
Programming Contest Sample Problems

Level 1 Problem: Fuel Efficiency

Write a program that produces a table of miles per gallon, (ranging from 2 to 40 M/Gal, by 2, i.e. 2, 4, ... 38, 40) and the corresponding kilometers per liter. The conversion factors are 1 Gallon = 3.785306 Liters, 1 Mile = 1.609344 Kilometers. Label and format your output. You need to have exactly 4 significant digits in the right hand column or have 10 minutes added to the time this problem was finished. The first two lines of the table are given below.

Mile/Gal	Km/Liters
2	0.8503
4	1.7010

Level 2 Problem: Armstrong Number Problem

An Armstrong number is a positive n digit number for which the sum of the digits raised to the n^{th} power is equal to the original number. For example: 153 is an Armstrong number because $1^3 + 5^3 + 3^3 = 1 + 125 + 27 = 153$. In this example the digits were raised to the third power because 153 is a three-digit number. The number 1634 is an Armstrong number because $1^4 + 6^4 + 3^4 + 4^4 = 1634$. Here all the digits are raised to the 4th power because 1634 is a four-digit number. Write a program that produces all the Armstrong Numbers less than 10,000.

Level 3 Problem: Longest Plateau in a Sorted Integer List

Determine the length of the longest plateau in a **sorted** list of at most 50 integers. A plateau is a sequence of consecutive numbers in the list that are equal.
Example:

Input --> -4 -3 -2 0 0 0 1 1 1 1 3 4 5 5

Output-> The length of the longest Plateau is 4

Notice that the number 1 appears four consecutive times in the list and the list is sorted.

Level 4 Problem: DICEY

To make board games like Monopoly® more interesting, we've invented many-sided dice. That is, while a normal die can be rolled for a 1, 2, 3, 4, 5, or 6, we've got dice which can roll 1 or 2; 1, 2 or 3; 1, 2, 3 or 4; 1, 2, 3, 4 or 5; etc. (Our patent for this is still pending so we can't tell you how we've done this. Suffice it to say we used extra dimensions.) As usual, the total on the dice is what counts. In addition, we always use three dice. We only sell the dice in sets which all have the same number of sides. So when games are played all the dice have the same number of sides. Notice if we use three, of the five-sided dice the possible totals are 3, 4, 5, ..., 15. Write a program which when given the number of sides on the dice, gives the probability of each total as a fraction. For the purposes of this program you may assume that the number of sides on the dice will be ten or less. (Actually we've hit a snag in producing eleven-sided dice, so this is good enough for the moment.)