Learning through Competitions – *Competition-Based Learning* (CBL)

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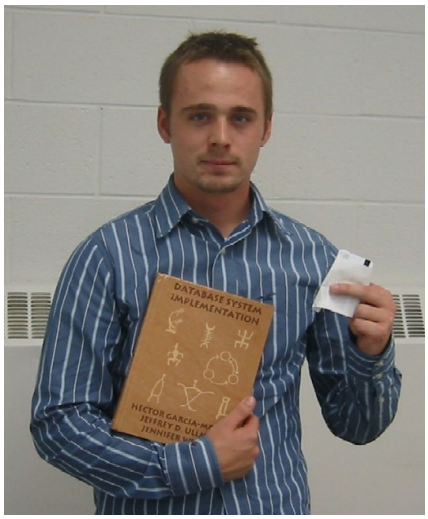
Tell me and I'll forget; show me and I may remember; involve me and I'll understand. - Chinese Proverb

Active learning is important in classes. One of the best ways to let students be actively involved in class would be to introduce classroom competitions. Classroom competitions has been motivating and promoting students to work harder. Usually, when the competition problem is assigned to the students, students are asking more questions than regular home works. Increased number of questions was asked to the instructor via emails. Even students try to learn beyond the normal classroom curriculum in order to win the competition. The classroom becomes learner-centric or student-centric environment. Some case studies show the benefits of the class competitions to enhance the learning.

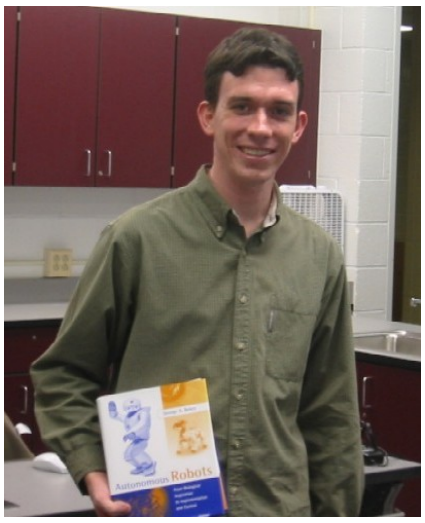
Case Study 1:

Based on the above teaching philosophy, I have introduced some assignments as class room competitions in my classes. For example, in the fall 2006 semester in "Intelligent Systems" class, two of the 7 assignments were competitions.

The first competition was to design & implement an algorithm to guess intelligently *n*-digit secret numbers you have in mind. You, as a tester, are supposed to score just the number of correct digits in the correct position for each secret number. The learning objectives of this problem were to think about vast search space and to design a practically efficient search algorithm that can be run in polynomial time. They were given two weeks to develop the program. Unlike traditional home works, they started the work on the day the competition was assigned, since I got many emails asking questions about the problem. Many students stopped by my office to demonstrate their current versions if they were satisfying the competition requirements.



The winner of the first competition was Philip Munie (see a picture left). His program was flawless and passed all 4 test case files. The hardest case file contained 15 digit secret numbers. Average number of guesses for the 15 digit numbers was 49. He received a book as well as $10 bookstore gift card as prizes personally donated by the instructor.



The second place winner was Shawn Ellison. See a picture left. Even if his program failed in solving the 15 digit case, his algorithm outperformed that of Philip Munie. His average number of guesses for 12 digit numbers was 28 as compared to 31 by Philip. Shawn also received a book as a prize.

After the competition, they were given opportunities to share their algorithms designed and experiences.

The second competition in the fall 2006 as the last assignment was to design, implement, and train an Artificial Neural Network (ANN) that will enable a robot to follow a solid or dashed line. Students were given web cameras to be used as a vision sensor for the laptop robot. As a specific requirement, students were asked to use ES (1+1) with 1/5 rule algorithm to train the ANN. Due to the limited class time in just one semester, students were not actually driving the robot, but displaying or animating the robot's direction to go when it sees the line on the floor via the web camera. This assignment integrates many concepts learned in class such as Evolutionary Computation, ANN, Adaptability, and Computer Vision.

The winner prize (Best Buy $15 gift certificate personally donated by Dr. Chung) went to Gary Givental, who passed all the different test cases perfectly. His training time was less than 5 seconds and he achieved near zero (0.1E-5) training error optimization. After the competition, he had a chance to share his ideas, algorithms, know-hows, and learning experience with his classmates.

Case Study 2:

In the fall 2007 semester in the Intelligent Systems class, we had a special classroom competition to solve the traveling salesman problem (TSP) that searches for the shortest route to visit a collection of cities and return to the starting point. Despite an intensive study by mathematicians, computer scientists, operations researchers, and others, it remains an open question whether or not an efficient general solution method exists. This problem was chosen especially in 2007 in order to celebrate Euler's 300th Birthday since one of the first instances of the traveling salesman problem was from him. The classroom competition problem, however, was more difficult with an additional constraint: there exists a list of two neighbor cities, *n* and *m* that must be visited right after. For example, if *n* is visited, then *m* must be visited right next. (Or if *m* is visited, then *n* must be visited next).

Students were asked to use either branch-and-bound based A* algorithm or Evolutionary search algorithms learned in class to solve the "NP (nondeterministic polynomial time) Hard" problem. The competition was held on December 4th, 2007.

The overall winner of the competition was Erica Stephens (1st picture below). Her program using A* like algorithm was flawless and solved all the 5 test cases. She received a LTU cup (soup bowl) as well as a $10 bookstore gift certificate as prizes sponsored by Math and Computer Science Department. There were two special prizes winners:



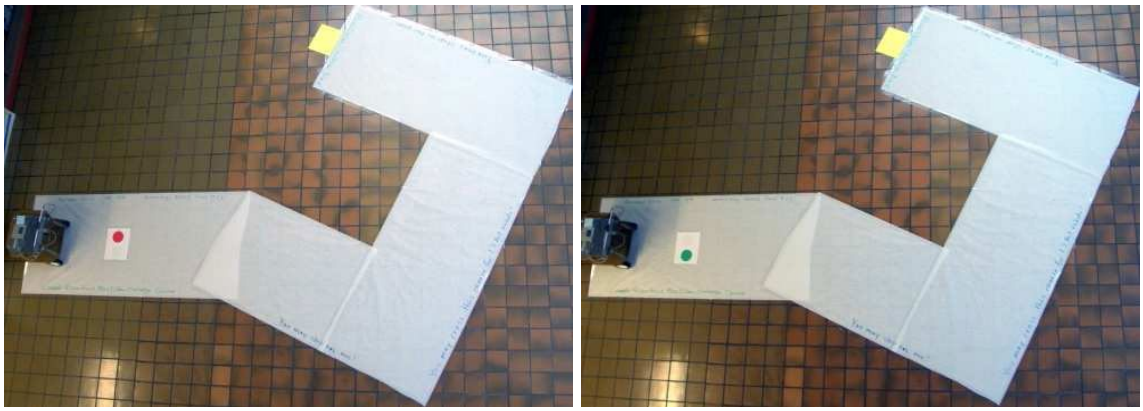
Nathan Lucas (2nd picture above) gave the best result for the 14 cities problem in Burma. His evolutionary algorithm gave 34.88. Best known solution is 33.23. He received a $10 bookstore gift certificate as prizes sponsored by Math and Computer Science Department.

Ghassan Tahhan (3rd picture above) won an LTU cup sponsored by Math and Computer Science Department. His solution was the best for the 51 city problem created by Elion and Christofides. The best known solution is 426. Ghassan's solution was 513.61.

Case Study 3

Even students were more excited to participate in open competitions. Intelligent Systems class in the fall 2007 was designed to enter a public competition, fall Mini Urban Challenge.

The open challenge was to follow a road made of 3' wide white paper. There was a letter size yellow paper at the end of the road. The robot must stop at the dead-end and come back home. The robot does not need to stop at the home when it comes back. The actual road shape was unknown until the day of competition. 90 degrees was the sharpest angle to turn. The floor color is a sort of brown. The robot starts when the green traffic light on the floor is shown to the robot. In the beginning before the start, red traffic signal light is placed on the floor as shown in the picture below. During the road following the robot must stop whenever and wherever the red light is presented to the robot on the floor. It was encouraged for college students to use artificial neural net architecture to train the robot for the challenge. The following pictures show another sample course setup in the atrium with the initial condition with the red light (left picture) as well as the green light (right picture).



Obviously students worked very hard. There were around 50 spectators including a staff writer for a newspaper on the competition day, December 18, 2007. The video of the competition can be accessed on the YouTube at http://www.youtube.com/watch?v=iskawd1DWSY (over 460 people watched this video so far)

Especially the winner Nathan Lucas's program was extra ordinary. He developed new methodology to training ANNs incermentally. His work is worth while publishing a paper. Later, he had an official class presentation in the spring 2008 semester.

Summary and Conclusion

Competition-based learning (CBL) can be defined as a student-centric learning paradigm combining project-based learning (PBL), Problem-based learning (PBL) and competitions.

Observation shows that students had higher motivation through class competitions. They asked more questions to the instructor. Students took responsibility for their own learning. Students worked more seriously. In some cases, students worked beyond the class topics. Students had a sense of ownership for their own learning. Students spent more time on the problems than traditional assignments. In general, class competitions enhanced the learning objectives in the class. A drawback of this approach was less cooperation was observed between teams. This problem was partially solved by requiring presentations to share their ideas and solutions after the competition.

"Prizes for achievements in promoting science, mathematics, engineering, or technology education … The Secretaries of the military departments and the heads of defense agencies may each carry out a program to award cash prizes in recognition of outstanding achievements that are designed to promote science, mathematics, engineering, or technology education in support of the missions of the U.S. Department of Defense." -National Defense Authorization Act for Fiscal Year 2003 (H.R. 4546, Sec. 2374b)

Prizes for the competitions were not the major factor for the motivations, but they certainly helped.

Education is the kindling of a flame, not the filling of a vessel.

Class competition could be a way to kindle a flame in classes. In addition, it will be helpful for our students to be the leaders in the future.

Educating the entrepreneur mindset to students in order to win and survive in these global competitions in the real-world becomes important. Geoff Nicholson, Former VP at 3M

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