Model Students

by Robert Emro

Against upper-class mathematics majors, they didn't dream they would make it past the qualifying round, but a team of first-year engineering students thought it would still be fun to try the Mathematical Contest in Modeling in the spring of 2012.

Singaporean Dennis Chua'14 ChemE first learned of the contest in Math 2930, Differential Equations for Engineers. Chua knew Alvin Wijaya '15 EE had already completed the class the previous fall and was taking a more advanced math class, so he asked the Indonesian if he wanted to give it a go.

"We needed a third person," says Wijaya. "Jessie Lin seemed like the best choice because she had also taken that class the first semester." Jessie Lin '15 EE had competed in math contests in her native Shanghai, but none involved modeling and they were only a few hours long. The modeling competition took four days. "I like using math for applied stuff, that's why I became an engineer," says Lin. "Both of us (Alvin) are pretty good at math, so I thought, 'Why not try it?'"

For the initial round of the contest, in which they were competing against other Cornell teams, they were asked to devise a model to determine whether a traffic light would improve pedestrian and vehicular traffic flow at the busy intersection of Tower Road and East Avenue, near Uris Hall.

Wijaya handled the research, making a field trip with Dennis to observe another traffic light on campus, near Carpenter Hall. "I trekked down there at night while it was raining to see how a traffic light works," he says. "The problem statement was super vague, so we went the extra mile and did primary research which is really helpful, because I'm pretty sure not one of the other groups thought of doing that."

"I remember us freezing out there," says Chua. "It was fun."

For four days, the three spread out on the floor of Alvin's or Dennis' dorm room to work on their model. "It was like lack of sleep and lots of coffee," says Lin. "We had a good time. Because we spent so much time together those four days we got to know each other pretty well and became good friends."

"I basically did like all the math parts. I came up with all the formulas," continues Lin. "We actually had a really good team because we were good at different stuff."

"I was the guy that did most of the coding. I was the kid who knew how to use MATLAB," says Chua. "It was crazy; I was literally writing code for every single minute of the day for four days before the competition. It was a ton of code. My computer couldn't take the programming I was doing. I wanted to run 100,000 iterations but I pressed enter and it died. I tried just ten and it did the same thing. Finally I tried three and it worked."

The team figured a properly timed light would improve flow at the intersection, but did not recommend it. "We found out that by varying the length of the red and green lights, and synchronizing with the lights at the bridge on North Campus, it would improve it," says Wijaya. "But in the end, we concluded that a traffic light there would be bad because students would cross against the light. We determined pedestrian bridges would be better. During class transition periods it would be so dangerous for people to cross there."

The three submitted their paper with little hope of winning. In fact, Chua did not even go with Lin and Wijaya to hear the winners announced. "I was a freshman and I thought there was absolutely no way I could have made it to the next round," he says.

"We knew we did well, but because we were competing against junior and seniors, people who had done the competition once or twice, we just felt that experience-wise, we were defeated really bad," says Wijaya. "But we felt we had a chance. We went there not expecting much, maybe top five and we were announced as the second place winner."

Second place qualified them for a berth in the international competition, in which they would be up against more than 3,600 teams from all over the world. This time they chose Problem A: The Leaves of a Tree, which tasked them with developing mathematical models to estimate the actual weight of the leaves on a tree and to describe and classify them.

"They give you one piece of paper with the problem, no information at all," says Chua. "There's no guidelines. There's no data for you to check your models on. It was a really, really a broad thing that required you to spend a whole day just zooming in on the ideas you want to focus on.

Again, Wijaya did the research, finding values to plug into their model, including tree height, branch angles, and bifurcation rates. "We had no clue about trees and leaves and all this bio stuff, so we had to do a ton of research," says Chua. "That really got me looking into bio stuff. I'm now doing all I can to become a biomedical engineer. Hoping to do a biomedical master's when I graduate." He's now assisting biomedical engineering assistant professor Jan Lammerding with muscular dystrophy research.

"Jesse was the math whiz who turned out all the formulas," says Chua. "She came up with all these crazy formulas. I don't even know how she did it."

Holed up in a dorm room together for hours on end with little sleep, the students sometimes worried they weren't up to the challenge. "Especially me, because I did the coding, so if I fail, this is not happening," says Chua. "Many times I had to rethink the strategy. Most of the time I was just learning, reading from my textbook. We hit a lot of walls where it was 'Dennis cannot code that.' I'm not a computer science major."

After four days, the students emerged with a simulation-based approach using probabilistic and dynamic models based on established research. "You put all the parameters into this model, like say it's in the alpine region, at what temperature, what time of year, what height of tree you're looking at, and out comes the weight of all the leaves on the tree," says Chua. "For our other model, the result that comes out is what kind of leaves does this tree typically have. Does it have a sword-shaped thin leaf? Does it have a big palm leaf?"

Despite all their hard work, the students had small expectations. "I honestly had no confidence that we were going to win. We were against computer science seniors. They have some really solid coding skills," says Chua. "I knew when the results were going to come out and I didn't bother checking, because there's no way you're going to win. You're one team from Cornell, only freshman, there's no way! We didn't find out until two months later when Alvin checked the Website."

What they found out was that they finished ahead of all other U.S. teams attempting that problem, including MIT, UCLA, and Harvey-Mudd College, landing them the Mathematical Association of America Award.

Lin couldn't attend, but that summer, Chua and Wijaya presented the team's winning project at the largest annual mathematics conference, MathFest 2012, hosted by the association in Madison, Wis. They were interviewed by renowned mathematician Frank Morgan, the Atwell Professor of Mathematics at Williams College, and subsequently featured in his blog entry about the MathFest 2012 in *The Huffington Post*.

"I would say one of the things that I learned from this is confidence," says Lin. "Even though you are a freshman or sophomore, you can do some pretty amazing stuff."

Dennis Chua and Alvin Wijaya with their award at the MMA.

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