Intel ISEF—Profiles of Success

Persisting Despite Challenges

Learning From Setbacks

"We spend too much time getting students to prove what everybody knows anyway. Turn it into something where student and teacher don't know the answer. That's real science."

—Simon Pugh-Jones
Head of Physics, Writhlington School
Bath, England

Research projects don't always proceed smoothly or unfold according to plan. Student researchers, just like adult scientists, sometimes get stuck during the process. An invention that looks good on paper may not work in the prototype stage. Test results may point the researcher in a new direction, throwing off the projected schedule. Challenges may arise when it comes to finding the right materials or laboratory equipment. Students describe how they have learned from setbacks and reflect on what keeps them motivated when challenges inevitably arise.

Multimedia Tutorial
Luis Duarte, Rodrigo Velasco, Jose Navarrete

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His Own Robot
Yik Hei Chan

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Demands of Aviation
Andreas Neuzner

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Creating Something New
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Grappling With Game Theory
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Hyeyoun Chung, an 18-year-old student at St. Paul's Girls School in London, turned her curiosity about a popular board game into a tough mathematical challenge: Why did certain strategies always lead to victory? While working out the proof, she also managed to teach herself complex computer programming skills. Then she learned how to create a graphical user interface so that a human player could compete against a computer that's been programmed to win. But it wasn't all fun and games, "There were some hard bits," admits the student who developed the project during her summer holiday. Read more.

A Study in Persistence
Alex Morris

Alex Morris, a student from Tapton School in Sheffield, England, set out to accomplish what he at first considered a fairly simple task: design an experiment that could measure slight changes in the properties of a material when exposed to a magnetic field. He soon found out, however, that creating an experimental model involving magnetism was not so simple.
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The students attend a public school called C.B.T.i.s. No. 168 (Centro Bachillerato Technologico Industrial y de Servicios). The school has a strong focus on careers and technology.

Luis Duarte, Rodrigo Velasco, Jose Navarrete

Working Long Hours

Designing and programming their innovative software meant working "before, during, and after school for many months," the students said. After winning awards at regional and national science fairs, they participated as finalists at the 2004 Intel International Science and Engineering Fair (Intel ISEF) in Portland, Oregon.

At Intel ISEF, the students' exhibit drew interested visitors who wanted a chance to see the multimedia tutorial in action. Using videos, illustrations, sound, and text, the program explains how the central nervous system functions. Because medicine is a fast-changing field, the student programmers designed their software to be easily updated with new information.

Interactive elements allow a user to tailor his or her own tutorial. An animated "helper" appears on the computer screen to help the user customize a search, use online resources, or review a particular part of the content. "This could be used by students and teachers," the finalists explained. "We included small tests so the student can check his own learning."

"Human Venice" also includes a selection of games to reinforce what the user has learned. "This lets the student learn through play," the finalists said. For example, while a user plays a game that involves motor skills or reflexes, a diagram of the brain appears on screen. "It shows you—while you play—what part of your brain is functioning."

Getting these interactive elements of the software to work was the most challenging part of the students' project, but also "the most fun to work on. When we saw it work, that was our reward."

At Intel ISEF, the students earned a second-place award and US$1,500 in the computer science team division.

His Own Robot

Yik Hei Chan

When he was in the third grade, Yik Hei Chan of Hong Kong, China, watched a television show about a robot. Immediately, he wanted one for himself. Now 14, Chan has applied his understanding of computer programming to design a multifunctional robot he calls "Total Equip," designed to offer an affordable and improved approach to home security.

Yik Hei Chan

The waist-high robot, featuring a body made of a trash bin that maneuvers on skateboard wheels, was a crowd-pleaser during the 2004 Intel International Science and Engineering Fair (Intel ISEF) in Portland, Oregon. Chan, a student at CCC Tam Lee Lai Fun Memorial Secondary School in Hong Kong, explained why his robot offers better security than dogs or locks. "Fixed alarms can be tripped and dogs can be poisoned or distracted." His invention, in contrast, is an ambulant device designed to monitor a home or business without traveling on a programmed course. "That makes it hard to disable," the student explained. The robot also has communications features so that it can notify the police or fire department if it detects an emergency, and a built-in camera to capture images of potential intruders.

Budget Concerns

To make his robot work, Chan had to work on electronics and circuit design, programming, and mechanical design. He wanted to avoid the need for complicated installation so that cost would remain modest. "Emergent communications technologies are, fortunately, becoming more affordable (and effective)," he added, explaining his decision to incorporate wireless and mobile technologies. To meet mechanical requirements on a low budget, he used inexpensive components such as a trash bin to provide a shell, or body, for the robot.

Chan learned about programming by taking evening classes, beginning when he was in the seventh grade. "The other students were all adults." He said he stays motivated during a long-term project "because this is my interest. Learning more about technology is my reward."

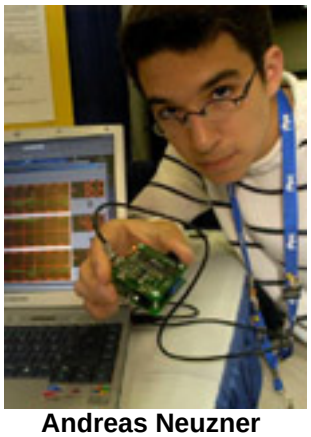
At Intel ISEF, Chan earned a second-place award of US$1,500 in the engineering category.

Demands of Aviation

Andreas Neuzner

Andreas Neuzner, 19, from the small town of Hüttenberg, Germany, was inspired by a story he read on the Internet about Maynard Hill, a retired American metallurgist with a love of model airplanes. On August 9, 2003, after many failed attempts, Hill and his volunteer team flew the world's first radio-controlled model airplane across the Atlantic, non-stop from Cape Spear, Newfoundland, to Mannin Beach, Ireland.

"I was excited about the idea and started to think about a similar project," says Neuzner, a senior at Butzbach High School. "But as I did more research it became clear that the most demanding thing would be how to stabilize the plane when gusts of wind knock it off its flight path. Most mechanical stabilization systems—such as gyroscopes—are too heavy and cumbersome for a small model airplane."



Andreas Neuzner

An Innovative Idea

For his science project, Neuzner decided to build a lightweight, non-mechanical sensor that would perceive when an object tilts, slopes, or turns, and send the information to a computer. In a model plane, for example, the sensor would register wind gusts and the computer would initiate corrective steering commands.

Working independently, doing research from books and on the Internet, Neuzner designed a schematic for a printed circuit board. A German electronics manufacturer donated the microchips, resistors, and other parts he needed to build his prototype. "The worst moment was when smoke came from the circuit board when I connected the wires wrong," Neuzner recalls.

His software program took about a year to write, working about 10 hours a week outside school hours. For specific questions, he used electronic newsgroups on the Internet.

The digital sensor Neuzner developed weighs about 50 grams, measures about 60 cubic centimeters, and attaches to a computer with a USB connection. The sensor tracks the movements of an object with three-dimensional animation, indicating when an object changes its resting position. Beyond aviation, Neuzner says future applications might include optical engineering and three-dimensional human interface devices.

The Benefits of Science Fairs

Neuzner is no stranger to science fairs. In 2003, he won the German Youth Science Project with a solar-powered MP3 player. In 2004, his teachers and schoolmates learned about his prize-winning digital sensor project at Jugend Forscht, the largest student science fair in Germany, only when they read about him in the newspapers. In 2004, he traveled to Portland, Oregon, as a finalist in Intel ISEF.

Along the way, Neuzner says, he has learned that "even the best projects can be damaged by a poor display and handwritten posters." The second-most important thing competitions have taught him, he adds humorously, "is that the level of food rises from sandwiches at the district level, to cold buffets at the regional level, and finally to noble restaurants at the federal level."

Creating Something New

Igor Kreimerman

"Many objects around us such as trees, mountains, and rivers have a fractal nature—meaning, small portions of an object are similar in shape to the whole," explains Igor Kreimerman, 18, a senior from Jerusalem, Israel. "For example, if we cut a branch off a tree, we find it looks very similar to the tree itself."

Knowing that every fractal has a value called a fractal dimension, Kreimerman wondered if there was a way to represent natural objects mathematically. He tackled his problem with the help of his math teacher, Nahum Freidmann, a professional mathematician at the Israel Arts and Science Academy, a residential high school in Jerusalem where students focus on experimental science, visual arts, or music.

Kreimerman soon discovered, however, that the fractal dimension by itself was not going to give him answers. "Then I noticed that when I calculated the fractal dimension with a computer, precision errors appeared," he says. "So I decided to try to use the pattern recognition that came from errors to solve the problem."

Creating New Knowledge

The work was hard, and Kreimerman spent many hours on ideas that didn't work out. "Sometimes I felt that it would be better to give up, but what kept me motivated was the possibility of creating something new, something that nobody has known before me," he says. The student's persistence paid off when he succeeded in creating a computer model, "Pattern Recognition Using Computer Precision Errors in the Estimation of Fractal Dimension."

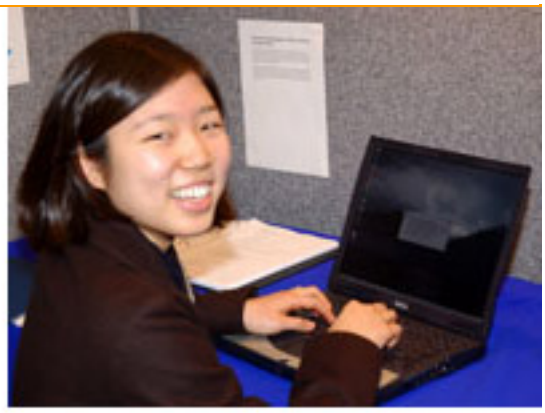
Kreimerman figures his model could be applied to a variety of uses. For example, aerial photographs, which typically have to be pored over by experts to be understood, could be analyzed more precisely with computers. Botanists in the field might also be interested in his work, he says. "It can take up to several hours to identify a plant, but if you have a laptop and digital camera, you could speed up the process."

At Intel ISEF in Portland, Oregon, an engineer who saw and was impressed by Kreimerman's display told him he knows someone at NASA working on the Mars Mission who might be interested in using optical photography and pattern recognition to identify soil types. "I hope to make contact with NASA in the near future," the student says hopefully.

Taking his project to the local science fairs in Israel, Kreimerman learned better ways to present his project to people who know nothing about his subject. "In our world of scientists, each one of us works in our own small area, and if we know how to explain ourselves simply, it will help all our work," he says. "That's the reason I'm here," he said at Intel ISEF, "not for the prizes, but to make contacts with future scientists from around the world." Kreimerman's project won fourth-place award, and US$500, in the mathematics category at Intel ISEF.

Grappling With Game Theory

Hyeyoun Chung



Hyeyoun Chung, an 18-year-old student at St. Paul's Girls School in London, turned her curiosity about a popular board game into a tough mathematical challenge: Why did certain strategies always lead to victory? While working out the proof, she also managed to teach herself complex computer programming skills. Then she learned how to create a graphical user interface so that a human player could compete against a computer that's been programmed to win. But it wasn't all fun and games. Admits the student who developed the project during her summer holiday, "There were some hard bits."

Her persistence has paid off. Chung's project, "Game Theory in Action: Proving and Computing Winning Strategies for the Game 'Nim' and Its Variants," earned honors at the 2003 BA CREST Science Fair in London. She was invited to attend Intel ISEF in Cleveland, competing against other student researchers from around the world. Impressive results, indeed, but especially so given that Chung began with only a brief classroom explanation of the underlying principles.

Getting Started

Chung describes herself as someone who has always liked math. During her summer break, she happened to start reading a book about games. "It has a little bit of mathematical background in it. And I read about the game Nim and thought, wow, that sounds really interesting. Why don't I investigate this topic a bit more? It kind of snowballed from there. I ended up doing one little thing and then expanding it and expanding it, trying this variant, that variant."

What initially intrigued her were a set of simple instructions for how to play the board game. "Basically, if you followed them from beginning to end, you would always win the game. So I thought, why should that always be true?" She decided to write a mathematical proof for why certain strategies always generate a win.

Next, she chose five variants of the game, and proved winning strategies for those, as well. Her approach: "Sort of playing with the games myself and trying to discover what worked, and why. How I tried to prove it was by setting out a series of logical steps that said this is true, therefore this is true, therefore you must win the game."

Next Steps

That sequential logic reminded Chung of computer programming. She had learned some programming fundamentals at school. "That kind of gave me this idea and made me think, oh, I can actually do this," she says. Getting the program to work took more persistence, however. "Something seems quite simple when you do it in your head or with a piece of paper. But to write it down in a way that the computer can follow explicitly, that was hard. And I hadn't had much coaching in programming beforehand."

Her teacher, Nick Abbott, praises Chung for being able to build on a classroom foundation. "She applied the good practices that had been taught to her and then, using a few simple tools and reference books that she had at her disposal, has developed a real understanding of the depth and power of Java as a mathematical tool," he says.

When Chung set out to work on her problem, she sent her teacher an email about her idea. He worried that she "had bitten off more than she could chew." However, a couple weeks later, he was delighted to receive another email that included her solution. "It is by far the most impressive piece of programming I have ever seen for someone of her experience," he says.

Lessons Learned

Along with the mathematics and computer programming Chung learned through her project, she also has gained some insights into the habits of mind that lead to success. "I've learned that it's really important to write down every single idea that you have. If you wake up in the middle of the night and have an idea, you're not going to remember it the next morning," she says.

What's more, she understands the importance of "formalizing your ideas. It might sound OK to you in your head, but you should always write it down clearly so that anyone can understand it. Make sure that it is actually a true and logical statement."

When she launched into her investigation, Chung had no plans to enter the results into a competition. But she decided to enter a school fair and came away the winner. Then she heard about the BA CREST Science Fair, which draws contestants from across the United Kingdom. "I thought that would be nice to enter," she says. She gained much more from the experience than high marks from judges and an invitation to attend Intel ISEF. "It's a great opportunity for people who like science and for students who have been working really hard on their own projects," she says. "You get a chance to see what everybody else has been doing. You get to meet people, like the judges, who are really interested in what you're doing. You get some practice in explaining what you've done so that other people can understand it as well."

A Study in Persistence

Alex Morris

Alex Morris, a student from Tapton School in Sheffield, England, set out to accomplish what he at first considered "a fairly simple" task: design an experiment that could measure slight changes in the properties of a material when exposed to a magnetic field.

He soon found out, however, that creating an experimental model involving magnetism was not so simple. The challenge was made harder because he was working with materials so thin, "the physics principles that are used in everyday life are no longer applicable." And he could not consider his experiment a success unless he managed to create "reproducible results. This was my main obstacle," he says.

Summer Project

Morris spent the summer of 2002 at the University of Sheffield, working alongside researchers who are attempting to improve on existing technology for storing data. As Morris explains, "The technology being used to increase the amount of information that can be stored on a computer hard drive is reaching its limit; new technology needs to be developed." The research group at Sheffield is attempting to create a more sensitive detector, permitting greater data storage per unit area.

Morris received a Nuffield Foundation bursary to fund his summer project. Although he was working in a university setting, much of his work was conducted independently. What kept him motivated, despite challenges, "was the knowledge that my aim was achievable," he says. Nonetheless, he had to spend considerable time modifying the apparatus he was using. "This was frustrating and demoralizing at times," he admits.

His breakthrough came about when he discovered that a magnetic connection block within the solenoid was disrupting his test results. "When the block was replaced by soldered joints, reproducible results could be taken." Other researchers are now implementing his new experimental design in their research.

Persisting until he found the solution has taught Morris an important lesson. "The project allowed me to build on my problem-solving skills and has greatly increased my stamina," he says. The most important things he learned? "Remember to consider the simple things. Expect the unexpected."

Better Communicator

Preparing a research project for competition also has helped Morris to develop his communications skills. At the 2003 BA CREST Science Fair in London, Morris found he enjoyed explaining his project to the judges. "I could see I had managed to enthuse them, and this was rewarding," he says. But what he calls "the biggest surprise of my life" came during the awards ceremonies when he learned he would be representing his country at the EU Young Scientist Finals in Budapest in September. "It was totally unexpected," he says. "I was smiling so much, I could barely say thank you!"