Science & Math CESE Education

The BEACON

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President's Message

On behalf of the CESE Board of Directors, I wish to thank all of the many people who made the CESE annual meeting such a success. We were lucky to have Nick Matzke of the National Center for Science Education (NCSE) as our keynote speaker. For those of you who missed it, Nick was an insider for the plaintiffs (the good guys) in the Dover Pennsylvania Kitzmiller v, Dover Board of Education trial last fall. Nick was the primary technical consultant to the plaintiff lawyers and as such, provided technical and strategic support to the legal team. He did this with insight and devastating effectiveness. He wondered if the "textbook" *Of Pandas and People* proposed for use by the Dover school board may have had its origins as a pure creationist book as opposed to an ID book as claimed by the Dover school board. It turns out he was right, and the revelation of this, among several other similar revelations, nailed the Dover school board's coffin shut. This was a truly insightful presentation and we thank Nick for coming to Albuquerque to speak.

On a different tack, last spring our official CESE statistician, Walt Murfin, at my request, reduced and analyzed performance data for the Rio Rancho school district. After his presentation he was invited back, and now has been invited back again to present his results to middle school teachers. This will be an all- day event with different groups of teachers throughout the day. Walt's analyses apparently got someone's attention, just as they did when Walt and Marshall Berman were collaborating with the NM Department of Education, now the Public Education Department.

One of the major things that Walt's analyses show is which schools are performing significantly under or significantly above expectations (95% confidence) broken out demographically. The demographics include percent minority, poverty, etc. This can be an incredibly useful tool for school districts. It tells them where to look for success as well as telling them where to concentrate resources for improvement. Of course, a well-administered school district will already have a pretty good idea as to where the extremes of performance are for its schools. But the district will not have the level of detail ranking by demographic variable. It appears that Rio Rancho has noticed this and is acting. (For those of you who are curious. Rio Rancho does very well when compared to the rest of the state.)

Walt's analyses bring up another issue: the No Child Left Behind (NCLB) act. Taken at face value, the NCLB's primary goal is admirable. Essentially, the act is simply intended to raise student performance. However, as usual, the devil is in the details—all 700 to 800 pages of details. The act requires that all students score at or above "proficient" by 2014. Additionally, the specific level that defines proficient becomes higher every year. Great goals! Unfortunately,

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Dr. David Johnson, Webmaster

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if you read “proficient” as being average, then this is an impossible goal. This has been pointed out by many people. Everybody cannot be above average, by definition! The act is up for renewal next year, and we can hope there will be changes. In fact, there are a number of problems with the act. But raising the hurdle that students are required to pass (Annual Yearly Progress – AYP) every year and requiring every student to be at or above average are two of the most egregious flaws. Note that the way AYP is defined makes it essentially impossible for the highest performing schools to pass the AYP test each year. When all students are performing at the top (not really possible with a large population), then there is no place else to go – except college, perhaps. Yes – all schools can improve, but no sizeable school can have all students perform above average. Additionally, some demographic groups likely to be underperforming are counted more than once. E.g., a student who may be poor, a minority, and not proficient in English will be triple counted if s/he fails to meet the proficient level. This is really hard on a school that may have an abundance of students in these multiple categories.

Basically, NCLB is a huge mess, and New Mexico students may only benefit minimally, if at all. So, in the meantime— until NCLB gets revised or dumped—one of the best ways to improve school performance in New Mexico is to use Walt’s analyses with the goal of bringing up schools’ performance levels. This can be done by identifying where schools are over-performing according to predictions based on their demographics, and determine how these schools are able to do this. Then, apply what is learned to other schools with similar demographics that are not adequately performing.

If anyone reading this is connected with the PED, and wishes to learn more, please contact me at kimber@comcast.net or call 897-3364 (H) or 247-9660 (W). We really are here to help.

Kim Johnson
President

CSI: Socorro–Science Education for the Digital Generation

Television was supposed to be the educational breakthrough of the 20th century, but it fell short of its potential. Now educators are faced with the challenge of inspiring a generation raised on the rapid-fire pace of television and video games. A bright spot for science education recently emerged; the popularity of shows that emphasize the scientific method in solving crimes. At the New Mexico Institute of Mining and Technology (NM Tech) in Socorro, we are taking advantage of the student fascination with crime scene shows to stimulate the interest of high-school students in science.

CSI: Socorro is a high-school mini-course that focuses on forensic genetics and gives students experience in modern techniques used in molecular biology, including micropipetting, gel electrophoresis, and polymerase chain reaction (PCR). In addition, the students encounter the science behind forensic DNA analysis; Mendelian transmission genetics, DNA structure and function, and molecular evolution. The course evolved from the independent project of Scotia Kurowski for her Master's of Science Teaching degree from New Mexico Tech, and a National Science Foundation grant to Rebecca Reiss that provided an Applied Biosystems' Prism 310 Genetic Analyzer for university-level research and for student training. The Prism 310 is an automated DNA sequencer and is the instrument that the FBI recommends for fluorescent genotyping used for forensic DNA analysis. Funding from the National Institutes of Health (NIH) assists with instrumentation maintenance since it is also used for research. Rather than discard expired reagents for forensic genotyping, police departments from as far away as St. Louis donate the reagents for instructional purposes. In addition, Applied Biosystems donated reagents. Assistance with forensic DNA techniques is provided by Catherine Dickey, a Forensic Scientist at the Bernalillo Metropolitan Forensic Science Center. The course is taught by Rebecca Reiss, Scotia Kurowski, and Mary Robinson, a forensics teacher at Rio Rancho High School.

In this week-long course, students first extract DNA from their own cheek cells and use enzymatic amplification to detect the presence or absence of a repeated segment of DNA. Next, the students learn about the short repeated sections of DNA used for forensic typing and prepare their DNA for capillary electrophoresis on a Prism 310 Genetic Analyzer. The techniques students learn are the same as those used in forensic science laboratories. In the finale of the course, students apply their new skills to a 'crime scene' to solve a mysterious death. The crime conveniently occurs the night before and involves a fall from the third floor balcony of Jones Annex on the NM Tech campus. The body (a mannequin purchased from eBay) is found on the pavement and the lounge and balcony contain obvious signs of a struggle. After inspecting and sketching the crime scene, each group of students collects evidence that may contain DNA, such as cups, sunflower seeds, and cigarette butts. They are also provided cotton swabs containing DNA from the victim and several suspects. Each group is responsible for the analysis of part of the evidence, and the data are shared with the rest of the class. On the last day of the course, each group presents their conclusions and recommends which suspect should be prosecuted. Students take this task very seriously, despite the obviously fictional crime scene, victim, and suspects.

Students also watch a video from A&E called 'Traces in Blood,' a program about a murder in New Mexico that includes an interview with Catherine Dickey, our collaborator at the Bernalillo Metropolitan Forensic Science Laboratory in Albuquerque. When possible, a field trip to the laboratory is included so students can see a real crime lab and talk to forensic scientists.

Students enrolled in the mini-course receive one college credit hour and they are exposed to university-level teaching. The involvement of high school teachers in the course assures that the

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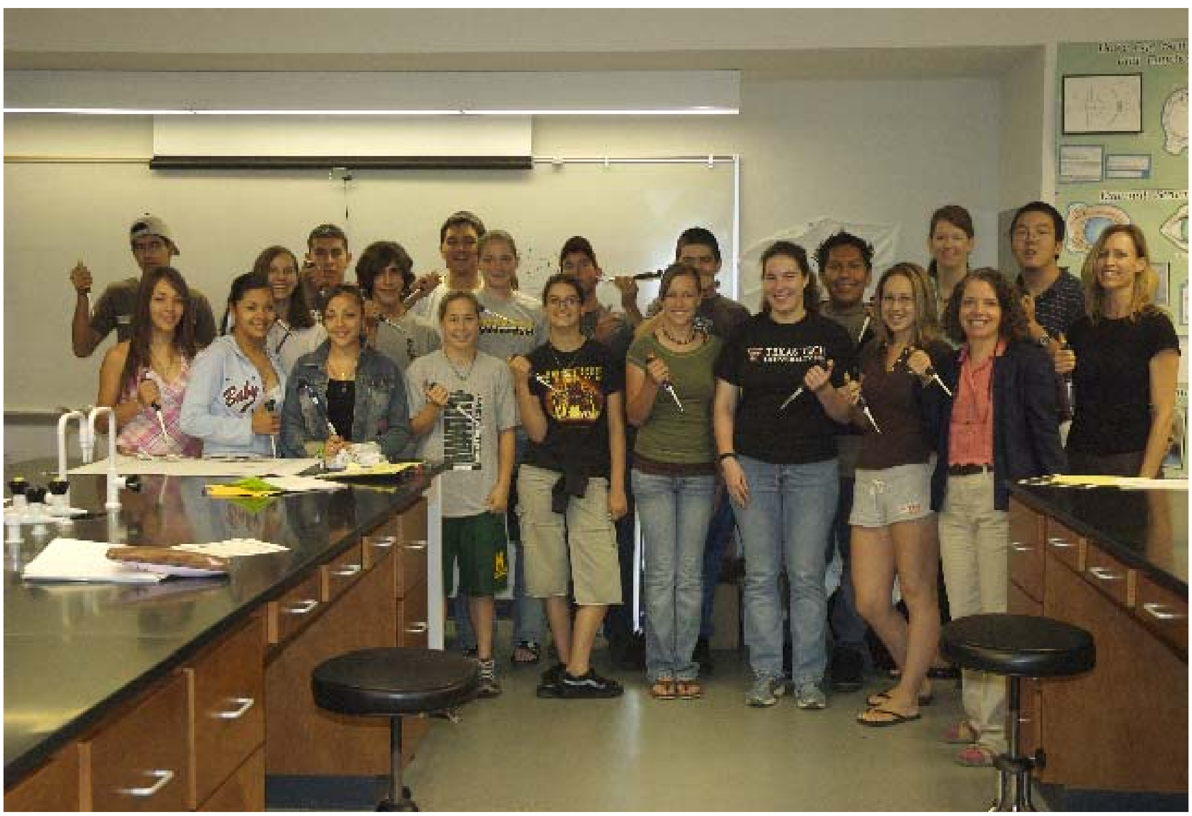
delivery of the material is complemented with effective secondary teaching strategies so the material doesn't overwhelm students. This balance provides the opportunity for students to develop modern biology skills, learn and apply the scientific method, and have fun. High-school teachers benefit from this experience by gaining exposure to advanced instrumentation and faculty mentoring. Faculty benefit from high-school teacher input that make this experience more productive for high-school students.

CSI: Socorro is one of several mini-courses for high school students offered by NM Tech in the summer. The next session is scheduled to be held in June of 2007.

Dr. Rebecca Reiss
Associate Professor of Biology
New Mexico Tech



Armed and dangerous, the participants and instructors of CSI: Socorro 2006 are ready to do some micropipetting.

Back to Basics

Statistical and testing terms have been discussed before, but maybe it's time for a refresher. These are really basic, and we hope it won't be too painful to go over them again. Some people actually involved in statistics and testing often misuse the terms.

"*Probability*" has two meanings: (a) the long run frequency of occurrence of any value in an event, or (b) our state of belief in the likelihood of occurrence of any value of an event. The first definition is easy to understand. If a big jar has twice as many black beans as white beans, and they are well mixed, a whole lot of beans chosen blindly have a probability of 0.66667 of being black and a probability of 0.33333 of being white. The second definition can be thought of as a fair bet. I put up $2; you put up $1. If the next bean is white, you get the whole pot. If the next bean is black, I get it all. We both think this is a fair bet. Some adherents of each definition insist that theirs is the one right way. For most purposes, there is no difference.

"Random" does not mean unpredictable. Randomness implies probabilistic predictability. If there is a stable pattern in the frequency of occurrence of measurements, then and only then can the phenomenon be called random. We don't know, will never know, will probably never want to know which specific molecules will combine in a chemical reaction. All we need to know is the probability that a certain fraction will combine. It is possible that there is no such thing as randomness above the Heisenberg level. Maybe if we knew everything, we might have the luxury of living in a mechanistically predictable universe. We will never know everything, so we are stuck with the fact that some events really are random. Creationists make a big fuss about the randomness of evolution, implying that "random" is in some way unacceptable. Of course, like most people, they have no idea what the word means.

A *"random variable"* is a probabilistically predictable quantity. The *"distribution function"* is a rule for the probability of any specific value of a random variable. The term is often shortened to just "distribution." Any occurrence of a random variable is an event, and the specific value of the random variable in an event is a *"realization."* The so-called *"normal curve"* is a mathematical idealization that fits some phenomena fairly well. It isn't normal in the sense that anything else is perverted and evil. Many sociological quantities are close to normally distributed; many are not even close. Unfortunately, many statistical calculation methods have normality as one of the underlying assumptions. We are likely to pretend that everything is normally distributed so that we can use those time-honored methods.

The *"probability density function"* (p.d.f.) is perhaps the most widely used and totally misunderstood quantity in statistics. The p.d.f. for a normal distribution is the familiar bell curve. The height of any point on the curve is NOT the probability of occurrence of the value on the horizontal axis. It is the probability of an occurrence in the immediate neighborhood of the value. It tells us how tightly bunched the points are. A variable that is spread out will have a low peak. That doesn't mean that it's unlikely. It just means that it is spread out. Unfortunately, almost no one understands what the curve means. That's not surprising, it is a difficult concept to grasp.

The *"cumulative distribution function"* (c.d.f.) is more useful but also difficult. Values of a random variable are ordered from lowest to highest. The height of the c.d.f. for any value of the variable is the probability that any realization will not be greater than that specific value. The c.d.f., strictly speaking, applies to a theoretical rule governing the probability of occurrence. For real-world quantities, the analog is the *cumulative frequency distribution.*(c.f.d) If a sample is large enough, the c.d.f. and c.f.d. are the same.

That brings us to *"population"* and *"sample."* The population is the entire universe of possible

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measurement values. For example, test scores of all the 4th grade students in New Mexico constitute a population. Suppose we blindly picked out 1000 test scores. We tried to do this in such a way that every student's score had an equal probability of being selected. That would be a random sample. If the sample is large, it is probably representative of the population. If it's small, we probably can't count on it being very close to the population.

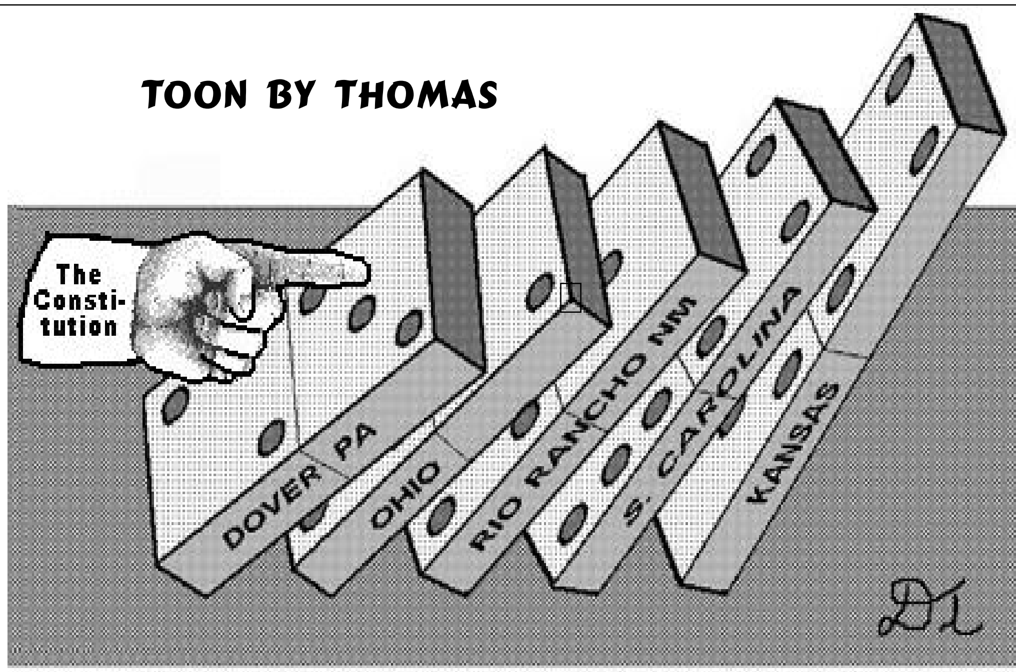
"Significance" or *"significant"* are almost always misused. We don't mean "pretty big" or "what we think we see." The terms have a very specific meaning. We might say, "I think there are more black beans than white beans in this jar." That's our experimental hypothesis. We blindly grab a handful of beans and count black and white beans. Sure enough, there are more black than white. Does this mean our hypothesis was correct? Hardly. Maybe we just didn't get enough beans for a representative sample. If the number of beans in the sample was large and black strongly outnumbered white, we can say our hypothesis was more likely true. We can calculate the probability that our hypothesis is wrong and should be rejected based on the size of the sample and the black to white ratio. By convention, we say it's "significant" if there is only one chance in 20 that we will be wrong in accepting our hypothesis. That is a far cry from the way the term "significant" usually gets thrown around.

All these terms have very specific meanings. The meanings tend to be different from what quite a few people (note: do not say a significant number!) think they mean. They are difficult concepts to grasp. It's necessary to make the effort if you want to understand statistical terms. However, here are two great and powerful rules.

- *Statistics can't prove anything!*
- *Correlation does not imply causality!*

Those rules ought to be easy enough to understand, but apparently very few have taken them to heart.

Walt Murfin
CESE Staatistician



"Intelligent Design" Policies in Schools, *Or,*
"The Domino Theory Revisited..."

"The War of the Weasels"

"Genetic Algorithms" are computerized simulations of evolution, and are used to study evolutionary processes, and also to solve difficult (and sometimes intractable) design or analysis problems. Creationists and Intelligent Design proponents often criticize these algorithms for not generating true novelty, and claim that the "answer" is sneaked into the program via the algorithm's fitness testing functions. Creationists always cite Richard Dawkins's "Weasel" tutorial simulation from The Blind Watchmaker, which does include a precise description of the intended "Target," the phrase "METHINKS IT IS LIKE A WEASEL" from Hamlet, during "fitness testing" on the numerical organisms being bred in the computer.

In 2001 I developed my own Genetic Algorithm for solving "Steiner's Problem": given a two-dimensional set of points, what is the most compact network of straight-line segments that connects the points? (Additional "Steiner Points" besides the fixed points are allowed.)

I posted a detailed discussion of this work on the Panda's Thumb blog (in July 2006, specifically to demonstrate that Genetic Algorithms can solve difficult problems without being given the answer(s) in advance. Additionally, these solutions themselves possess "Irreducible Complexity" (IC) and exhibit "Complex Specified Information"(CSI), two features which Intelligent Design theorists claim are impossible via evolutionary processes. The ID community responded to my article by reiterating their claim that the solutions were secretly introduced via the Fitness function.

On August 14th, I posted a public "Design Challenge" in which readers were asked to submit answers for a tricky six-point Steiner system by August 21st. It was an open-book test. Since the ID person responding to this (Bill Dembski's blog assistant, Salvador Cordova) claimed the answer was already present in the Fitness test, I challenged him to follow that lead to the Answer. However, Cordova went the traditional route, and tried to design an answer the old-fashioned way, using Fermat Points and trigonometry. Interestingly, Cordova failed to find either actual solution to the six-point problem, finding instead a slightly longer "MacGyver" solution with the wrong network. However, 15 other people derived the correct answers, and these were also found by not one but two independent Genetic Algorithms! Thus, ID theorist Cordova has learned the hard way of the true meaning of what Daniel Dennett terms Leslie Orgel's Second Law:"Evolution is smarter than you are."

Cordova also posted his code for a "genetic algorithm" that he contended could solve for the sum of the first N integers, without specifying the answer. However, I proved that his program was, despite copious amounts of smoke and mirrors, simply a direct method of specifying the answer, or "target." In this summer's "War of the Weasels," only evolution can claim victory. Visit **www. pandasthumb.org** for the complete story.

Dave Thomas

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