Science & Math CESE Education

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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 helped make the CESE annual meeting on June 16, 2007 a splendid success. We were honored to have Dr. David L Goodstein, vice provost and a professor of physics and applied physics at the California Institute of Technology (Caltech), as our keynote speaker. Dr. Goodstein was the host of television's popular "The Mechanical Universe" series on PBS. David's topic was "The end of the age of oil." Dr. Goodstein began by listing several common myths and misconceptions: "$3.00 is too much to pay for a gallon of gas; oil companies produce oil; if we don't conserve energy, we will have an energy crisis; when the oil supply is gone, the marketplace will replace it with something else; there's enough fossil fuel in the ground to last another 100 years; nuclear energy is dangerous." One of his major points was that "the supply of any natural resource rises from zero to a maximum point, and then it falls forever. Oil will behave in the same way." Natural gas could be a very good clean-burning substitute for oil, but it will only be a temporary solution, and will probably lag oil in its eventual decline of availability by only a decade or two. Coal can also be used to replace the missing oil, but it would have to be mined at a much higher rate, at least five times beyond what is done now. Even then, it may only replace oil for a century or so. Goodstein said that fissionable nuclear power is also limited: to produce enough fission power to equal the power we currently get from fossil fuels, 10,000 of the largest possible nuclear power plants would have to be built. Nuclear fusion is a desirable alternative, but will not be practical for decades, if ever. Goodstein's conclusion was that there will be an oil crisis very soon – "If we burn all of the remaining fossil fuels, they will all probably start to run out by the end of the 21st century. Assuming that our planet remains habitable after such a vast consumption binge, we will have to invent a way to live without fossil fuels."

Kim Johnson is to be commended for his stellar performance as CESE President for the 2006-2007 year. I only hope I can be as effective in the upcoming year. One of the highlights of the Annual Meeting was a review of the previous year's activities. These included testifying by several CESE members at the New Mexico Legislature this spring, during hearings on the so-called "Academic Freedom" bills introduced by State Senator Steve Komadina and State Representative Walter "Dub" Williams. These bills rode the crest of the latest incarnation of "Intelligent Design Creationism," which, after having been soundly defeated in the 2005 Dover trial, is trying to re-define itself as merely advocating teaching "all" evidence, including (conveniently) "evidence against evolution." However, since every citation of "evidence against evolution" that's been put forth can be traced directly to creationist roots, it has become evident that the only "Academic Freedom" the bills' supporters really care about is the "Academic Freedom" to teach creationism in public school science classes.

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WEBMASTER: Jesse Johnson

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There are some new things to keep an eye on. The Discovery Institute, the Seattle-based "Think Tank" that is the main supporter of "Intelligent Design," has crafted a very tricky new book targeted for public schools. It is called "Explore Evolution," and is careful not to mention "Intelligent Design," much less creationism. This slick "inquiry-based education" book has thirteen main sections, covering topics like Universal Common Descent, the Cambrian Explosion, Anatomical and Molecular homology, Embryology, Biogeography, Natural Selection and Mutation, the flagellum and its irreducible complexity, Survival of the Fittest as a tautology, Gaps in the Fossil Record, and more. Our 2006 Annual Meeting speaker, Nick Matzke, has described the book's approach as follows: "Each of these seven sections follows a tiresome, formulaic tit-for-tat format: First comes an 'Arguments For' subsection, where the evidence for a strawman version of the mainstream scientific view is incompletely and incompetently presented. Second, an 'Arguments Against' subsection presents the recycled creationist objections to the standard view, but always disguised as the views of a diverse collection of 'some scientists' who are 'critics.' Finally, a 'Further Debate' subsection piles on more creationist argumentation, again in the disguise of 'some scientists,' and predictably concludes that, really, this line of evidence for evolution really is terribly debatable, and the debate should go on." The book is riddled with misconceptions and misrepresentations of real science, but is careful to avoid First Amendment complications. There is no law requiring books to actually represent science honestly.

We're asking you to keep an eye out for this slick-looking tome in New Mexico's public school classes. Texas could be the first real test for the book: Don McLeroy, a member of the Texas State Board of Education, and the recently-appointed chairman of the Board, is a strong advocate of "Intelligent Design." In a 2005 speech at Grace Bible Church in Bryan, Texas, speaking on an "Intelligent Design Theory Primer," McLeroy was, unlike most Intelligent Design proponents, remarkably candid to the church audience. He told the group "Whether you're a progressive creationist, recent creationist, young earth, old earth, it's all in the tent of intelligent design."

I'd like to thank all of the hard-working members of the CESE Board for their ongoing efforts on behalf of sound science and math education. Walt Murfin, CESE statistician, has another fine article in this issue of the Beacon. Kudos also to CESE Secretary Marilyn Savitt-

Kring, whose notes on Dr. Goodstein's talk were invaluable for this letter.

Finally, it is with great sorrow that I mention the passing of former CESE president Tim Moy (2001-2002 term) in a tragic swimming accident in Hawaii this summer. Please read Kim Johnson's moving tribute to Tim in this issue. A number of CESE members attended the memorial held for Tim at UNM's Keller Hall, and the CESE web page (at www.cesame-nm.org) has several remarks about Prof. Moy's passing by CESE members. The comments on the CESE page by David Moy, Tim's father, were especially moving, and I'll close my letter with his words:

"Betty and I would like to thank everyone who expressed such warm and loving comments about Tim. To read all of the tributes to him as a teacher, colleague and friend just makes us proud that he carried himself so well, especially in the eyes of his peers. Tim was passionate about learning and about teaching, and it was no surprise to us that he rose to join you in your fight to teach science, and science only, in science classes. He spoke many times about CESE and the great work that you accomplished to allow NM schools to do their job in teaching and training the future doctors and scientists. And we hope that his spirit will always live on in CESE as you stand to safeguard the integrity of the NM school system. Thank you again from the bottom of our hearts."

Dave Thomas

Timothy David Moy

May 9, 1963—July 22, 2007

In Memory of Tim Moy

I am sure that all who knew Tim Moy already know the circumstances of his death by drowning on July 22 while trying to help his son in the surf in Hawaii. Much has been written in Hawaiian newspapers, in Albuquerque newspapers, and in the Daily Lobo – UNM's newspaper. Tim Moy was a tenured professor of history at UNM specializing in the history of science, among other topics.

Tim was a very special person. He was a past president of CESE and an active supporter of the mission and goals of CESE. He has been characterized in many ways, almost all noting his depth and breadth of knowledge, his engaging personality, his commitment to getting at the basis of all phenomena, including social. Many have spoken of his ability to speak to people concerning almost any topic. But he has also been mischaracterized as someone who merely wanted to study phenomena such as the creationist movement in order to bring people together. In fact, Tim wanted to study phenomena so that he could learn, and act on what he learned, to accomplish goals he thought were important. Tim was not an impartial bystander, but rather the quintessential observer with a purpose who acted on his beliefs after studying the situation. He did not believe that all viewpoints are equal, but that many are contradicted by the evidence. He felt that understanding the motivation of some people was absolutely necessary when personal engagement had proven to be impossible on divisive topics of current interest. At the same time, Tim had the rare ability to pull back and emotionally remove himself from the fray to actually look for understanding of a situation to determine how best to act – on topics ranging from science literacy to nuclear power. That is an ability we should all strive to achieve.

A grand memorial for Tim was held at UNM. The hall has a capacity of about 350 people, and all seats were taken, with some people standing. Many people spoke about Tim and mentioned his engaging style, his sense of humor, his lack of pretense, his almost unbounded interest in everything. But I think that no one touched on one of the very key things that made Tim special: When Tim spoke with you, you felt like you were one of the most important people in the world. He was this way with everyone. No one was too small, and no one was too big for Tim's attention. He wasn't naïve, but he did not seem to have any need to pretend that he was superior or inferior to another person. To an observer such as me, all people were equal in Tim's eyes. That doesn't mean that he considered all people right – just equal at the most fundamental level as enumerated in the US Constitution, and, as I understood Tim, equal at the visceral level. How many of us can say that we see people in the same light? We should.

It still doesn't seem real. I close my eyes and see Tim's face. I hear him speak. I hear him laugh. I see his face crinkle around his eyes with humor. Tim will never be out of my mind as long as I shall live. I am thankful for the time that I knew Tim and feel both privileged and more enlightened for having known him. We all wish the best for his family, especially Rebecca his wife, and Luke his son.

Kim Johnson

IMPORTANCE AND SIGNIFICANCE

The terms "importance" and "significance" are virtually synonymous in general usage. But **significance** has a specific statistical meaning. It does not mean large, or noticeable, or valuable, and does not always mean important. A result is significant if the probability of the experimental result being due to random chance is suitably low. By custom, a probability of five percent is generally accepted. If the chance of error due to variability of the data is greater than one out of 20 we usually question the result. If our sample is very large, even trivial results can be significant. For example, if we tested every fourth-grade student in the United States, and were very careful to record scores correctly, there is no possibility of an error due to sampling "jitter" in the data. Even completely meaningless results could be significant.

In most education work, we are dealing with a limited number of schools or students. The number of known demographic variables is limited. Variables that are intuitively expected to be important often turn out to be not significant. Variables that do not seem important are often significant. Significance simply means we stand little chance of error by accepting an effect. It means that if someone tries to replicate our results, there is only a small probability that we will be embarrassed. If a result is not significant, the variance attributable to the experimental effect is overwhelmed by the "noise" variance. The experimental effect can be large, but the noise effect is also large.

Importance could be measured in several ways. We can focus on two. In one method, we consider how much each variable adds to the explanatory power of all the other variables. This is done by calculating the fraction of variance in the dependent variable (Y) attributable to all of the independent variables acting together. Then we calculate the fraction of variance attributable to all the independent variables except the one for which we want to assess importance. The difference of the two fractions of variance tells how much that one variable added to the explanatory power of all the others.

A second method is probably easier to visualize. We ask, "If we increase this independent variable by one standard deviation(SD) holding all other variables constant, how many SDs difference will that make in the result?" If we find that increasing X1 by one SD increases Y by 0.5 SDs and increasing X2 by one SD reduces Y by 1.5 standard deviations, then we would say that X2 is more important than X1. This method has the advantage of showing the direction of the change in Y as well as the magnitude.

For a test of **importance** and **significance** let us take all the large elementary schools in New Mexico – those that tested at least 40 students in Spring 2006. As the dependent variables, we will use the fractions proficient or better in mathematics and reading. As independent variables, we will take the fractions of minority students, of English language learners (ELL), of special education students, and of students eligible for free-or-reduced-price lunches (FRPL), the school size, and the stability of the student population. (The last variable is the ratio of full academic year students to total enrollment.)

Only three variables (minority, FRPL, and school size) turned out to be significant for mathematics performance. Three variables (minority, ELL, and FRPL) were significant for reading performance.

We can rank all variables by descending order of significance (increasing probability of error) even including non-significant variables. We can also rank variables by their unique contribution to the total explained variance

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Descending Order of Significance		Descending Order of Contribution to Explained Variance		Descending Order of Efffect of Change on Outcome	
Math	Reading	Math	Reading	Math	Reading
% Minority	% Minority	% Minority	% Minority	% Minority	% Minority
School Size	% ELL	School Size	%ELL	% FRPL	%FRPL
% FRPL	% FRPL	% FRPL	% FRPL	School Size	% ELL
Stability	Stability	Stability	Stability	Stability	Stability
% ELL	School Size	School Size	School Size	% ELL	School Size
% Spec. Ed.	% Spec. Ed	% Spec. Ed.	% Spec. Ed.	% Spec. Ed.	% Spec. Ed.

and by the change in the outcome associated with an increase of one SD in the independent variable.

All methods show that the fractions of minority and FRPL students are important, that stability is less important, and that the fraction of special education students is least important. The latter is true because most schools have small fractions of special education and the fractions do not differ much from school to school. There is reasonable but not quite perfect agreement for other variables. The order of importance is different for reading and mathematics.

School size is significant for mathematics and ELL is significant for reading. However, the effects of both are relatively small. An increase of one SD in minority fraction is associated with a reduction in math outcome of 0.567 SD. A one SD increase is school size is associated with an increase in math outcome of 0.125 SD. The effect of size is less than one-fourth the effect of minority fraction. The effect of English learner fraction on reading outcome is about one-third the effect of minority fraction.

We might have assumed *a priori* that high student mobility would seriously degrade performance. There is only a small statewide effect because the student population is quite stable in most schools. Mobility might be important in some urban schools, but those schools are not typical of the state. It might seem that having many students with limited English would seriously impact performance. That is true to some extent for reading, but not at all for math. English ability is very strongly correlated with minority status, and the high level of importance for minority fraction covers most of the English ability effect.

It is generally dangerous to postulate the relative importance of independent variables before carrying out the calculations. This is true for all fields, not just for school testing. Because many of the variables in this example are correlated with each other, the situation is actually more complex than appears here. Methods are available for quantitatively assessing the importance of individual variables; it is neither necessary nor useful to guess. It is necessary to understand that correlations and interactions between variables can obscure the measures of importance. Different methods of assessing importance can lead to different results. There is no one right way.

Walt Murfin
CESE Statistician

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I do not feel obligated to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forgo their use.

Galileo Galilei