Investing in the Future

Each February the U.S. government budget season begins when the Administration presents its budget request for the fiscal year beginning October 1. This presentation initiates activity in the thirteen corresponding House and Senate appropriations subcommittees. Several of these subcommittees oversee the budgets of agencies that support science research and education.

Over the course of the summer these subcommittees try to come up with agreements on the budgets of all programs and agencies falling under the discretionary part of the U.S. federal budget. Once the Congress finishes its work on the bills that contain these program and agency budgets, the bills are sent to the president for his signature. Once signed, these bills become law and these budgets are operational. Rarely are these budgets ready by October 1.

Observing this budget process year after year, I have come to the conclusion that the U. S. lacks a consistent, stable, transparent, year-to-year funding mechanism for supporting basic research across all disciplines of science and engineering. Not having such a mechanism inhibits scientific progress, quashes the morale of scientists, and deters young people from becoming scientists.

For example, basic research is increased by only 0.6% over fiscal year (FY) 2004 in the Administration's recent budget request. The year-to-year rate of increase of the total federal basic research budget has been decreasing since 2001, going up by 11.7% from FY 2001 to FY 2002, by 6.3% from FY 2002 to FY 2003, by 5.5% from FY 2003 to 2004, and now by 0.6%.

Looking more closely at the Administration's FY 2005 federal basic research budget is eye-opening. Basic research funded by agencies other than the Department of Health and Human Services (including the National Institutes of Health (NIH)) decreases by 2.46% over FY 2004. If the Department of Homeland Security funds are also subtracted, basic research drops by 3.36%.

The country's most recent model for funding science is the doubling model—more precisely, doubling in five years. This model was used successfully to double the budget of NIH. More recently this model was put forth in the guise of the National Science Foundation (NSF) Authorization Act of 2002, now Public Law 107-338. This established a schedule for doubling the NSF budget over the next five fiscal years. Beginning with the FY 2003 budget, the NSF budget was to increase by 15% a year over the preceding year, until it doubled the FY 2002 NSF level of approximately $4.8 billion to $9.84 billion in FY 2007. Passage of PL107-338 was greeted with much enthusiasm within the scientific community, since NSF supports science research across all disciplines (e.g. over 65 percent of all mathematical research carried out in academic institutions is supported through the NSF).

So far PL107-338 has had little effect, as the FY 2004 NSF budget is $5.58 billion, while the authorized amount is $6.39 billion, and the FY 2005 budget request sets it at $5.75 million, much less than the authorized amount of $7.38 billion. It is unlikely that the NSF budget will reach $9.84 billion in FY 2007.

Of course, the NSF budget should grow to $9.84 million sooner rather than later. But what happens after the goal is reached? What's the plan for future funding? Nothing in the law indicates how funding levels are established or how they should be maintained over time other than this five-year span. As we see with the NIH after "the doubling", Congress, the Administration, and the biomedical community are haggling over how to proceed with future funding—never mind all the young scientists entering the biomedical pipeline who will need to gain research support.

A consistent method of funding basic research across all fields of science on a year-to-year basis is needed. Doubling one agency at a time is not such a plan. Establishing a stable growth model that will enable all fields of science to prosper is critical. Such a model will support the needed scientific infrastructure that facilitates advances in many fields. Furthermore, this infrastructure will contribute to our national security.

The federal government needs to take note here. Investing in basic research is much like individuals putting money into their retirement accounts. Even though we may have debts or other pressures on our incomes, prudent individuals continue to invest, knowing in time their foresight will pay off. Society will also benefit from our foresight if we make steady, systematic, adequate investments now and over time.

History has shown that basic research is the basis of technological invention and economic growth as well as being critical to security. Congress and the Administration need to address the issue of science funding with the idea of developing a model that works fiscally as well as making sure that our basic research enterprise runs robustly. The scientific community should advocate for such a process and help to develop a feasible method for taking it forward.

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This is a modified version of an editorial that first appeared in the April 2004 issue (volume 2, number 3) of Frontiers in Ecology and the Environment. *Reprinted with permission of the Ecological Society of America.*

Letters to the Editor

Paper-and-Pencil Math

While ostensibly a critique of mathematicians who express interest in mathematics education (particularly those disagreeing with his views), Tony Ralston's article in the April *Notices* has a second but hardly subordinate theme: an updating of his ideas expressed in other writings on school mathematics. I think Tony is wrong in many of his pronouncements on school mathematics, starting with arithmetic.

On page 407 of his *Notices* article, Ralston tells us: "It may be that the teaching of pencil-and-paper arithmetic, which has been the gateway to the study of school mathematics for more than a century, is as important as it has ever been." This caution is not observed in his paper "Let's abolish pencil-and-paper arithmetic" [*Journal of Computers in Mathematics and Science Teaching*, volume 18, number 2 (1999), 173–194]. Although there we learn that Ralston wants youngsters to have some knowledge of mental arithmetic, when the going gets tough—when, for example, students might need a technique to add two 4-digit numbers or three 2-digit numbers that they cannot do mentally—then Tony would demur. Calculators to the rescue! At the very moment when addition is about to blossom into an algorithm—and perhaps the first algorithm that a child will see—Ralston declares it educationally unnecessary, writing in this 1999 article that "children should not be expected to learn these algorithms." However unhappy Ralston is with the Klein-Milgram paper on the long-division algorithm, his real opposition appears to be mastery by children of *any* pencil-and-paper algorithm of arithmetic.

Mastery of addition and the other algorithms of basic arithmetic act as a flashlight, allowing the young student to move freely about in the world of numbers and basic numeric operations. Without such mastery a young student is condemned to move about blindly in this intriguing unknown world of numbers.

Recently a student of mine came to my office for help in baby calculus. One of the problems had the expression 3(2/3). Naturally, I cancelled the two factors of 3 and said that the answer was 2. The student did not see why. So I wrote the equivalent improper fraction 6/3, and then it was clear to the student that the answer was indeed 2. This otherwise intelligent student had used calculators extensively since fifth grade at a very good school. This is an example of what I mean by "calculator-assisted mathematical incompetence".

I support the intelligent use of computer or calculator technology. Yet, while not every use of a calculator constitutes an abuse, students need to be held accountable for mastering the mathematics that they study. And part of that accountability should include homework and in-class examinations—the latter with *at least* restricted calculator use.

The standard arithmetic algorithms allow a teacher to communicate with students, and students with each other, to show *how* a given answer was obtained. And mastery of a standard algorithm is portable when a child moves from one school district to another. Each of these is an important consideration.

I am surprised to learn that Tony made no reference to one of his earlier and more provocative papers ["The really new college mathematics and its impact on the high school curriculum," *The Secondary School Mathematics Curriculum* (C. Hirsch and M. Zweng, eds.), Reston VA: National Council of Teachers of Mathematics (1985), pp. 200–210], where he writes: "No sound argument can be adduced to support a thesis that claims that high school students must be very skillful at polynomial algebra, trigonometric identities, the solution of linear and quadratic equations or systems of equations, or any of the myriad manipulative tasks that are part of the current high school curriculum." Where are the statistical studies supporting Ralston's more radical conclusions?

Do most mathematicians really share this view? I believe that they do not. Rather, I believe that the preponderance of mathematicians want students to internalize the procedures and processes of the traditional basics of algebra, geometry, trigonometry, and, yes, arithmetic before coming to college.

Although Tony Ralston will and should be castigated by some readers of the *Notices*, at least he has taken the time to express his views on school mathematics. His views have made their way into mathematics education circles because many mathematicians have left it to others to address the content crisis in school mathematics. I appreciate very much the work of research mathematicians, but I plead with them to allocate some of their time to school mathematics. In addition to some of the mathematicians cited in Ralston's article, we need more mathematicians with good judgment to speak out on this matter of national urgency.

Where are they?

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(Received April 9, 2004)

Geometry Texts for Teachers

Hung-Hsi Wu, in his review of Audun Holme's *Geometry: Our Cultural Heritage*, laments the lack of the fostering of geometric intuition in geometry texts and offers his own work with B. Braxton (available on the Web) as one way to achieve that goal. There are at least two other published geometry texts I know of that pay careful attention to that goal. One, meant for high school students but easily adaptable for future teachers, is EDC's (Education Development Center's) *Connected Geometry*, one of the NSF curriculum projects of the 1990s. The other is David Henderson's *Experiencing Geometry*, which has gone through various iterations (distinguishable by their subtitles), gradually becoming more and more comprehensive. Both books have high standards of mathematical correctness, mathematical depth, and careful attention to how students actually learn, and both are written with remarkable clarity. In fact, years ago while I was reviewing a draft of part of *Connected Geometry*, my seatmate on the airplane, who identified herself as someone ordinarily not interested in mathematics, got so intrigued while reading over my shoulder that she asked if it was available as a Christmas gift.

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(Received April 15, 2004)

Prisoner's Dilemma

Regarding the Prisoner's Dilemma, Steven E. Landsburg ("Quantum game theory", April 2004, page 395) says, "Rational selfish prisoners always choose the one strategy pair [i.e., the Nash equilibrium (D,D)] that both can agree is undesirable—in the sense that they would both prefer (C,C)." (Strategy D is to defect and C is to cooperate.)

Rational selfish prisoners should not choose the Nash equilibrium. Because the game is symmetrical for the two players and because both players are rational, then whichever strategy Player 1 decides is best, Player 2 will also decide is best. Thus, the only possibilities are (D,D) and (C,C). Since (C,C) is better for each player than (D,D), rational selfish prisoners should choose (C,C). The reason the Nash equilibrium is not relevant is that its definition considers pairs of strategies which are impossible if both players are rational, i.e., (C,D) and (D,C).

This is discussed in detail in Chapter 30 of *Metamagical Themas: Questing for the Essence of Mind and Pattern,* by Douglas R. Hofstadter (Basic Books, March 1996, ISBN 0-465-04566-9). Hofstadter notes that most people when presented with the above argument still say they would choose D.

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(Received April 19, 2004)

Work of Morozov, Weisfeiler, and Borel

Regarding the article on Armand Borel in the May 2004 issue of *Notices*, I would like to comment on the related important earlier contributions of Vladimir V. Morozov and Boris Weisfeiler, two eminent Russian mathematicians who are not with us anymore.

Comment 1 (cf. p. 510 of May 2004 issue): The conjugacy of maximal solvable subalgebras of a complex finite-dimensional Lie algebra was proved by Vladimir V. Morozov in the paper "On a nilpotent element in a semisimple Lie algebra", *Doklady USSR* **36**:3 (1942), 83–86 (in English).

Comment 2 (cf. pp. 517–8 of May 2004 issue): Let G be a semisimple algebraic group over an arbitrary field, let U be a unipotent subgroup of G, and let N be the normalizer of U in G. If U coincides with the unipotent radical of N, then N is a parabolic subgroup of G. This theorem was proved by Boris Weisfeiler in the paper "On a class of unipotent subgroups of semisimple algebraic groups", *Uspekhi Mat. Nauk* 21:2 (1966), 222–3 (in Russian). For an English translation of Weisfeiler's paper and related comments, see the arXiv: http://www.arxiv.org/math.AG/0005149.

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(Received April 29, 2004)

The *Notices* invites readers to submit letters and opinion pieces on topics related to mathematics. Electronic submissions are preferred (notices-letters@ams.org); see the masthead for postal mail addresses. Opinion pieces are usually one printed page in length (about 800 words). Letters are normally less than one page long, and shorter letters are preferred.