The Case Against Computational Tossups

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Let us dispel any early misconceptions: the three of us are all mathematics majors, and we well understand the beauty and importance of mathematics. We were all good at computation when we played high school Scholastic Bowl; we advocate its elimination not out of dislike for the subject, nor out of ignorance of it, but rather out of a concern for the incompatibility of computation with the nature of Scholastic Bowl.

The question of what constitutes a good question is one that the community will likely never agree on perfectly. However, we believe that a good question rewards players' knowledge, that the purpose of each individual question is to determine which player present knows the most about its topic, and that players who do not know the answer to a question (or a particular clue within it) should be able to learn from a good question or portion thereof. These conclusions exclude computational questions from qualifying for the label "good".

Computation tossups do not reward knowledge

The issue of rewarding knowledge and determining who has the most of it is a thorny one. Certainly, knowing how to solve a given problem can be considered a form of knowledge. (This point and its importance are themselves debatable, see *e.g.* Lockhart [2002][1], but the debate is irrelevant here).

However, what are we testing when we pose such a problem? We are determining who can do the computation *first*, that is, fastest. But this is meaningless! While testing whether someone can solve a math problem in a time limit is, in the context of high school, sometimes acceptably academic (and done by countless math teachers on exams, as well as on tests like the AMC and AIME), there is no value in testing whether someone can solve a math problem *before someone else solves it*.

Independent of the question of whether computation is a valuable skill, it is indisputable that questions requiring it are *fundamentally different in nature from every other Scholastic Bowl question*, in that they test an applied skill rather than knowledge of facts; the logical continuation of requiring computation is asking players to execute a chemistry experiment, dissect something, analyze a literary passage, etc. These are all valuable skills, but to test an applied skill of one discipline and ignore those of other disciplines is unfair to those skilled at other disciplines' applied skills, as well as simply illogical.

Computational tossups can certainly be written to require knowledge about a particular technique of solving problems, but there exist no such questions that do not require players to devote time to actually carrying out the computation—and it is at this point that the question turns into a test of speed rather than knowledge. Consider the following computational tossup[2], supposedly written pyramidally:

> This is the value of the double integral from *x* equals 0 to 2 and *y* equals 0 to 60 of *x* d*y* d*x*. It also equals the number of ways that the letters in the word GAGGLE can be arranged. It is the total surface area of a cube that has sides of length two root five. Give this number that is the smallest number equal to a prime number cubed times two other distinct primes.
> ANSWER: **<u>120</u>**

Suppose a player knows how to compute the given double integral. This is done as follows:

$$\begin{aligned}\int_0^2\int_0^{60} x\,dy\,dx &= \int_0^2 x\,y\Big|_{y=0}^{y=60}\,dx\\ &= \int_0^2 60x\,dx\\ &= 30x^2\Big|_0^2\\ &= 30\cdot 2^2\\ &= 120.\end{aligned}$$

There isn't even any setup to do—the setup is stated directly. However, executing each of these steps takes, at best, a couple of seconds, by which time the moderator will have read the GAGGLE sentence. The setup for that GAGGLE problem can be made and computed *much* more quickly than the double integral can be done; it is $\frac{6!}{3!} = 6\cdot 5\cdot 4 = 120.$ This computation is so

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[1] Lockhart, Paul. *A Mathematician's Lament*. New York: Bellevue Literary Press, 2009. Also available at <http://www.maa.org/devlin/LockhartsLament.pdf>

[2] By David Reinstein, written for the 2009 New Trier Scobol Solo (championship round, tossup 56).

quick, a strategic player will even buzz before having completed it, and finish it while waiting to be recognized. Therefore the player doing the “simpler” computation (based on when in a typical curriculum one learns how to do each)—letter rearrangements rather than a double integral—can easily buzz before the player doing the “more difficult/complex” one, effectively making the question *antipyramidal* by rewarding the player doing the easier problem. This situation gets even worse at the end, where “a prime number cubed times two other distinct primes” is very easily determined to be $2^3 \cdot 3 \cdot 5 = 8 \cdot 3 \cdot 5 = 120$, while a more skilled player will still be working on a previous clue. This question, therefore, rewards speed over knowledge or understanding; the “pyramidal” label is misleading.

Notice too that this tossup effectively has four “clues”: a double integral, rearranging the letters in GAGGLE, surface area of a cube, and its prime factorization. By contrast, NAQT’s question standards require *at least* seven clues per tossup, and most of their questions have more. Especially given NAQT’s 425-character limit on its tossups, this results in much higher clue density. Because math problems are often impossible to state in just a few words, it is all but impossible to have this many clues in a computational tossup without making it a page long.

Computational tossups written without the pretense of pyramidality are no better.Consider the following tossup[3]:

> Solve this equation over the real numbers. The log base 5 of the quantity two *x* squared minus three, close quantity, equals 2.
>
> ANSWER: $x = \pm\sqrt{14}$

This is most expeditiously solved as follows:

$$\begin{aligned} \log_5\left(2x^2 - 3\right) &= 2 \\ 2x^2 - 3 &= 5^2 \\ 2x^2 &= 28 \\ x^2 &= 14 \\ x &= \pm\sqrt{14}. \end{aligned}$$

Perhaps one player will take one second per step and another three, despite both knowing the same information about how to solve the problem. If Scholastic Bowl is supposed to determine who has more knowledge on a particular topic, as it is, such questions distort that goal; there is no correlation between the ability to solve a problem *quickly* and having the knowledge of how to solve it.

Additionally, computational tossups do not reward higher-level knowledge because of the limitations of the Scholastic Bowl format. There are relatively few fundamental types of problems that can be done in a short time limit; estimates range from 30 to 50 different types of problems, far fewer than the hundreds or thousands of topics that come up in other categories. The time constraints also skew these problems towards easier math and away from more advanced yet important topics in math. Teams good at math computation are very familiar with that set of 50 or so problems, but they do not necessarily know *why* their methods of solving those problems work. Because this canon so small, it is far more effective to simply memorize the methods of solving such problems without thinking about the mathematics involved.

Next, computational tossups differ from all other tossups in that a player may have complete knowledge yet be credited with an incorrect answer through a simple arithmetic mistake, misheard number, or such. In other categories, players who know the answer to the tossup first will certainly be rewarded. This is not true for computational tossups: someone who knows the material can (and due to racing is more likely to) make an error on an arithmetic component to the problem, receiving no points despite full knowledge of how to do the calculation. Until answers like “take the factorial of the number of letters in the word and divide by the factorial of the number of instances of each repeated letter” are acceptable to a math computation problem, this flaw will remain.

The combination of these flaws manifests in empirical evidence showing that computational questions are answered correctly far less often than those in other categories. From 2004 to 2009, NAQT collected data for 2,971 computational tossups read over the course of 22 tournaments, and found that computational math tossups were converted at a rate of 44%[4] (1,295 of those tossups were answered). This conversion problem is not unique to NAQT’s questions; on the 2009 Scobol Solo set written by David Reinstein, the nonpyramidal computational tossups were answered only 29% of the time[5]. For the sake of comparison, Northern Illinois University’s Huskie Bowl tournament, run February 6 on the Prison Bowl set, saw 94% of its

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[3] Written for the 2008 IHSA State Series (championship/round 10, tossup 9).

[4] Hoppes, Jeff. NAQT internal memorandum, supplied by Hoppes to Greenthal via email. 11 May 2009.

[5] Gauthier, Greg. “New Trier Scobol Solo conversion statistics.” *Quizbowl Resource Center*. 12 Nov 2009. PACE, Web. <http://www.hsquizbowl.org/forums/viewtopic.php?p=160514#p160514>.

tossups (none of which were computational) converted, and this in a fairly heterogeneous field playing a set designed to be slightly harder than usual difficulty.

Computation tossups do not educate

Another fundamental problem with computational tossups is that a player cannot learn directly from such questions. Consider as an alternative the following *noncomputational* math tossup[6]:

> One law concerning this function describes the radiant intensity from a certain type of surface, and is named for Lambert. The hyperbolic version of this function defines a catenary, and equals half the quantity *e* to the *x* plus *e* to the negative *x*. A double-angle identity for this function is that with an input of two theta, it equals the quantity one minus the tangent squared of theta over the quantity one plus the tangent squared of theta. Its Maclaurin series is one minus *x* squared over two factorial, plus *x* to the fourth over four factorial, et cetera; and its namesake law generalizes the Pythagorean theorem. Name this even trigonometric function that, for an angle in a right triangle, equals the ratio of the adjacent side to the hypotenuse.
>
> ANSWER: **<u>cos</u>**ine function [or *f* of *x* equals **<u>cos</u>**ine of *x*, etc.]

If a player buzzes after the first sentence, s/he learns nothing and the other players in the room all learn a bit about Lambertian surfaces. After the second sentence, everyone learns something about Lambertian surfaces and everyone except the buzzing player learns about hyperbolic trigonometric functions, and so forth. In the scenario with the *least* learning, every player but one learns a fact, while many gameplay situations will have more players learning more facts. This argument applies to every type of well-written question present in Scholastic Bowl except computational ones. Naturally, over the course of a tournament no one will remember every single fact that s/he heard, but a reasonably intellectually curious player (the kind we expect to be playing Scholastic Bowl!) should pick up a considerable amount of new information, particularly if s/he is responsible enough to take notes.

On the other hand, with the previously discussed question (ANSWER: **<u>120</u>**), no one can learn anything. Players who don't know how to evaluate double integrals will leave the match still not knowing how to evaluate double integrals, players who don't know how to rearrange letters will remain ignorant of that application of the factorial function, and so forth. Players who do know the underlying mathematics but not how to compute it *first* learn nothing about how to solve similar problems more quickly. Theoretically, a moderator could explain how to do each problem after the question is over, but that is not done, would be a ridiculous use of time, and would be beyond the expertise of many moderators.

What about bonuses?

Most of the problems with computational questions apply only to tossups—in particular, speed is irrelevant to bonuses. Computational bonuses are not, therefore, an inherent problem (though the difference that computation is an applied skill rather than factual knowledge remains). Too often, however, especially in IHSA format with four- or five-part bonuses, it is excessively difficult to do multiple interesting computations in the span of thirty seconds.

Question writers have tried numerous methods of writing computational bonuses, but these methods are flawed. The most common options include resorting to asking for insultingly simple arithmetic (a test which does not belong in a Scholastic Bowl match between high school students) or applying the same process to different numbers (in which case if a team knows the process, the number of parts they answer correctly is entirely speed-dependent). Furthermore, bonuses requiring computation often prevent one player from doing all the work on a bonus, an obstacle not present in bonuses in other categories. While computational bonuses are not as inherently problematic as tossups, they should be written with great caution to avoid the pitfalls outlined above.

What is to be done?

It is our belief that if *good* questions of a certain type cannot be written, then questions of that type ought not be written. Therefore, the solution is simply not to write math computation tossups!

But, you say, math is important to the high school curriculum, and therefore Scholastic Bowl ought to cover it. Certainly! And it can do so—much more effectively, indeed—without including computation questions. As the above tossup about the cosine function demonstrates, well-written *conceptual* mathematics questions are quite possible. Tossups can similarly ask about important theorems, techniques of problem solving, mathematical history, particular numbers and their properties, structures such as particular curves, and so forth. Replace math computation tossups with conceptual tossups, and there is no problem at all.

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[6] By Jonah Greenthal, written for the 2009 New Trier Varsity (round 4, tossup 8).

Already both national tournaments and every respected housewritten tournament in the country have made this move. As Scholastic Bowl in Illinois moves forward, it is time for us to adopt a distribution that understands the nature of our competition and promotes learning.

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