

Online Testing is Unsuitable for Senior School Mathematics

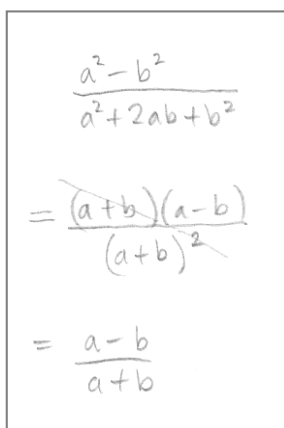
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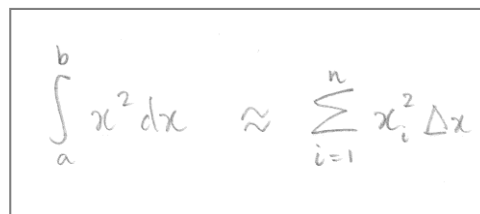
In this article, we consider why 'online testing' is not a valid way to test senior school level mathematics. By 'online testing' we refer to students in multiple locations, sitting in front of computers, reading test questions from screens and entering their responses, via internet connected software, within real time limits.

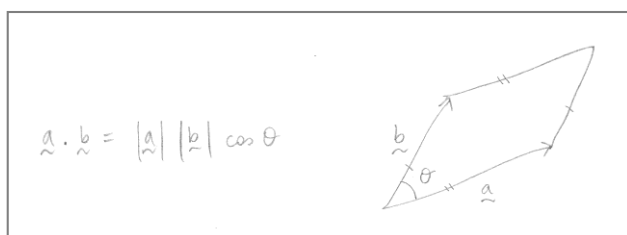
1. Incompatible Formatting

The first reason that online testing should not be used, is that present computer software and hardware are incompatible with the formatting conventions of mathematics.

To understand this incompatibility, recall that mathematics uses numerators and denominators, superscripts, subscripts, super-superscripts, cancellation, Greek letters, other special symbols and also involves frequent sketching of original diagrams. Consider for example, attempting to type into a computer these brief but typical excerpts from senior mathematics:


$$\frac{a^2 - b^2}{a^2 + 2ab + b^2}$$
$$= \frac{\cancel{(a+b)}(a-b)}{\cancel{(a+b)}^2}$$
$$= \frac{a-b}{a+b}$$


$$\int_a^b x^2 dx \approx \sum_{i=1}^n x_i^2 \Delta x$$


$$\vec{a} \cdot \vec{b} = |\vec{a}| |\vec{b}| \cos \theta$$

The formatting conventions of mathematics have been refined over hundreds of years, and are a critical, ingenious component of the discipline. They enable mere mortals to solve a wide range of useful and difficult problems.¹ As Newton said, "If I have seen further, it is by standing on the shoulders of giants."

¹ For a simple example of the power of mathematical formatting, consider attempting the problem of: multiplying three hundred and fourteen by five hundred and ninety-two by writing out each word in English, i.e. without using any numerals.

Even in 2014, the only convenient way to do high school (and much of tertiary) mathematics is still by pencil and paper. There is still no word-processing software, which is convenient or flexible enough to serve as this kind of support for the mind when actually thinking through mathematics.²

Much like we do not expect students to produce art on a computer, we should not expect students to do mathematics on a computer. Mathematical notation is too intricate to type in with a keyboard and mouse.

Asking examinees to write on a tablet computer, is also unsuitable for senior mathematics exams. Tablet writing is clumsy and messy compared with writing on paper, and tablet screens are not large enough to conveniently show the full page of working. The tablet software would need to be thoroughly familiarised by the examinees through much practice, to prevent the software features from becoming interruptions to the examinees' trains of thought. Tablet use for senior mathematics exams may be a possible vision for decades into the future, but is not a near reality.³

Due to this formatting incompatibility, any online testing of senior mathematics is limited to responses which do not require mathematical formatting, i.e. to short response and multi-choice questions. In the next point I explain why short response and multi-choice testing are unsuitable for assessing senior mathematics.

2. Limitations of Multi-Choice and Short Response Testing

A principal aim of school mathematics is to develop students' mathematical reasoning ability from being able to answer simple, one-step questions, to by the senior years, being able to produce long chains of clear, logical reasoning to arrive at correct solutions.⁴

Finding out whether a student has the ability to present long chains of clear, logical reasoning to arrive at correct solutions, requires giving them the opportunity to do so. At the senior level, this typically requires up to one page of written mathematical reasoning (with specific formatting and possibly diagrams).

² When mathematicians and mathematical professionals are finally ready to publish their results, they use software called *LaTeX*. This is the world standard and the best software for publishing mathematics, but using even this software is far too slow and cumbersome to use during the thinking and generating part of their work, let alone in a test, when time is critical.

³ Note that handwriting recognition software is currently nowhere near being advanced enough to interpret and format mathematics correctly. Banks and other companies take advantage of this situation by using recognition of spatial arrangements of handwritten numbers for computer security.

⁴ This ability should not be confused with the misplaced idea from education theory of 'higher order skills'. The ability to do senior mathematics has nothing whatever to do with completing long written research-style assignments.

A second aim of school mathematics, is to equip students with a knowledge framework consisting of standard mathematical methods. Whether a student is clever or not, learning these standard methods, will allow them to 'stand on the shoulders of giants' and solve a wide variety of problems. Unfortunately, multi-choice and short answer testing cannot identify those students who used the right method but made a 'silly mistake on the way'.

For the above mentioned reasons, online testing can not discover whether a student has achieved the principal goals of studying senior mathematics -- whether they have the ability to clearly present long chains of correct mathematical reasoning, and whether they have learned mathematics' standard procedures. Only 'traditional' pen-and-paper exams can do this. Rather than lifting the standard of mathematics, online exams would trivialise students' abilities in this subject.