

There's more to mathematics than grades and exams and methods

When you have mastered numbers, you will in fact no longer be reading numbers, any more than you read words when reading books. You will be reading meanings.
([W. E. B. Du Bois](#))

When learning mathematics as an undergraduate student, there is often a heavy emphasis on grade averages, and on exams which often emphasize memorisation of techniques and theory than on actual conceptual understanding, or on either intellectual or intuitive thought. There are good reasons for this; there is a certain amount of theory and technique that must be practiced before one can really get anywhere in mathematics (much as there is a certain amount of drill required before one can play a musical instrument well). It doesn't matter how much innate mathematical talent and intuition you have; if you are unable to, say, compute a multidimensional integral, manipulate matrix equations, understand abstract definitions, or correctly set up a proof by induction, then it is unlikely that you will be able to work effectively with higher mathematics.

However, as you transition to graduate school you will see that there is a higher level of learning (and more importantly, *doing*) mathematics, which requires more of your intellectual faculties than merely the ability to memorise and study, or to copy an existing argument or worked example. This often necessitates that one discards (or at least revises) many undergraduate study habits; there is a much greater need for self-motivated study and experimentation to advance your own understanding, than to simply focus on artificial benchmarks such as examinations.

It is also worth noting that even one's own personal benchmarks, such as the number of theorems and proofs from <standard reference text in your field> you have memorised, or how quickly one can solve qualifying exam problems, should also not be overemphasised in one's personal study at the expense of actually learning the underlying mathematics, lest one fall prey to [Goodhart's law](#). Such metrics can be useful as a rough assessment of your understanding of a subject, but they should not become the primary goal of one's study.

Whereas at the undergraduate level and below one is mostly taught highly developed and polished theories of mathematics, which were mostly worked out decades or even centuries ago, at the graduate level you will begin to see the cutting-edge, "live" stuff – and it may be significantly different (and more fun) to what you are used to as an undergraduate! (But you can't skip the undergraduate step – you have to learn to walk before attempting to fly.)

See also "[there's more to mathematics than rigour and proofs](#)".

I also recommend Keith Devlin's opinion piece "[In Math You Have to Remember; In Other Subjects You Can Think About it](#)". (Note: the title of the piece is actually the opposite of Devlin's (and my) opinion; read the article for the explanation.)

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[26 February, 2009 at 5:24 am](#) Hi Prof Tao,
kam



I have one question regarding learning of Mathematics. I am now currently first year undergraduate pursuing quantitative economics.

Consider now I am self-studying Calculus 1 ,2 and 3, would you recommend studying the Calculus in a conceptual way or rather the theory and rote learning way?

It takes me a lot of time to learn conceptually, but somehow I do not know the tradeoff between learning conceptually and the time is really worth it. However, learning conceptually helps me understand Calculus a lot more. I can understand multiple integrals but I cannot really grasp the concept of Calculus 2, since the Calculus 2 is more on technique to solve the problem rather than teaching the concepts.

I am rather stuck at this point now.

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[23 March, 2010 at 9:06 am](#) [...] problems to unsolved problems, is certainly
Solving mathematical problems – by Terrance Tao « Press4ward: faith, hope and love an important aspect of mathematics, though definitely not the only one. Later in your research career, you will find that problems are mainly solved by knowledge [...]

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[5 March, 2011 at 6:36 am](#) Sir,



Janson Antony A I'm a final year undergraduate student of Mathematics from Kerala, India. I'm one of those who really love Mathematics. Now I wanna learn something more Mathematics. But, I've got only 62% marks for my subsidiary subjects. I had applied for an integrated Ph.D course in TIFR, India. I've cleared the written exam and have been called for an interview. It's scheduled to be on the next week. But, I wanna know whether I'm eligible to do such a course, I don't know whether they would reject me because of my poor marks in the subsidiary subjects.

Actually I don't care about exams, sir. That's why I got such marks. I believed that these marks doesn't have anything to do with Mathematics. I think we only need to have much more interest and little talents to do Mathematics. I think what all we need is to have the mind of a Mathematician to learn Mathematics effectively. And I wanna be a Mathematics student till my death sir. It's my ambition. But, because of my marks I think I won't get an admission in any good institutions. So now I think that there's "much more to marks and grades than our interest in Mathematics." Do you think that I can reach my goal..?

I'm one of your big fans sir. We're really thankful to you for providing these helpful knowledge. Can you please give me an advice regarding my further studies, sir..

Janson.

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[5 March, 2011 at 9:48 pm](#) Can you please give me a reply on my question, sir..



Janson A.J

1 51 Rate This
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[22 September, 2011 at 6:15 am](#) Hi,



Yamauti, F.

I've just entered in a university (by the way, in Physics, but I always took more math subjects), however, at least in the universities of my country, people be more

concerned about grades then in self-studying or understanding rigorously. I like to study for me and enjoy (for instance, I hate calculatory exercises) and not for some exam. It looks like good, apparently, however I'm finding difficult in maintain my grades in a high level. Should I stop studying for me and, instead of it, study more for exams (that's what some teachers said to me)?

Apparently, people in my country prefer succeeding in the carrer then in studying for your own formation (a lot of people get high grades absent the knowledge about the things learned, they just apply an algorithm, however, in general, they don't know why it works) , but I think that this actions make the reason of why I like and study mathematics become empty. I like to think and open my mind, I don't want to be stuck and limited to this context. Any advice?

And sorry for my bad english.

Thanks anyway.

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[14 December, 2011 at 2:52 pm](#)

[...] questions", la pérdida de más de un estudiante de grado. (Ver ["La matemática es más que rigor y demostraciones"](#) | [bloccdemat](#) también: "There's more to maths than grades and exams and methods".) Pero la transición de la segunda etapa a la tercera es igual de importante, y no debería [...]

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[7 November, 2012 at 7:44 pm](#)

[rithika](#)

i love to know about maths and to learn maths and maths is a fun subject butt for me is hard cause i dont understand the questions so thats why i want to study more about maths



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[14 July, 2013 at 10:40 pm](#)

thank you professor tao! excellent blog!

Anonymous



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[19 July, 2013 at 8:55 am](#)

[...] Source:

[There's more to mathematics than grades and exams and methods | Singapore Maths Tuition](#)<https://terrytao.wordpress.com/career-advice/there%E2%80%99s-more-to-mathematics-than-grades-and-exam/#8230>; [...]

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[26 October, 2013 at 9:23 am](#)

Anonymous

That link to "In Math You Have to Remember; In Other Subjects You Can Think About it" is broken. I think it's been moved to http://www.maa.org/external_archive/devlin/devlin_06_10.html



[Corrected, thanks – T.]

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[7 February, 2014 at 4:02 am](#)

Someone who looking for concept is creator who create newest subjects of [Rattana-arpha Attohi](#) mathematics, another is guard.



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[12 February, 2014 at 5:37 pm](#)

Santiago Solano

Hello Professor Tao, just wanted to ask for your advice on reading mathematical papers, I figure that for anyone who lacks insight into the subject that reading papers would help, yet I must ask how does one grapple with the words being used? I struggle understanding the language being used in mathematics and wonder how does one overcome this hurdle? I ask because abstraction seems something distant and basically how I can come to a point of



understanding and perhaps more ease when facing things such as “degree asymptotics with rates for preferential attachment random graphs”, although I admit that reading that slowly and writing it out helped so that might be something. Thanks for reading,

Santi

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5 February, 2015 at 9:03 am

[...] is not

[Why the h-index is bad as an “objective” measure of individual scientific productivity | The Daily Pochemuchka](#) necessarily the case for most brilliant minds unfortunately), I quote a paragraph from this article – this was where I first heard of the law above by the [...]

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6 February, 2015 at 5:26 pm

[...] benchmark, such as obtaining degree X

[Career Advice by Prof Terence Tao, Mozart of Mathematics | MScMathematics](#) from prestigious institution Y in only Z years, or on scoring A on test B at age C. In the long term, these feats will not be the most important or decisive [...]

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11 July, 2015 at 5:57 am

[...] 解决问题，无论是对作业题还是对人类未曾解决的问题，当然都是数学学科的重要方

译：[解决数学问题 by 陶哲轩 | 万里风云](#)面，尽管这并不是唯一的方面。在今后你的研究生涯里，你会发现，人们往往通过知识（包括你自己领域和别的领域的知识）、经验、耐心、和勤奋工作来解决问题；但是对于中小学、大学、或者数学竞赛里的题目，人们需要一套稍微与众不同的问题解决技巧。我写过一整本关于在这个层面上解决数学题的书；而且，那本书的第一章就在讨论通用的问题解决策略。当然，市面上也有很多其他关于解决问题的书，比如波利亚的《怎样解题》——我自己在准备数学奥林匹克竞赛时，就在学习这本书。 [...]

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28 October, 2015 at 3:12 am

I love your topic sentences.

[phungtrongthuc](#)

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2 June, 2016 at 9:04 pm

[...] artificial benchmark, such as obtaining degree X from prestigious institution Y in only Z years,

[Terence Tao's Advice – ashadianand](#) or on scoring A on test B at age C..Of course, one should still work hard, and participate in competitions if one [...]

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18 July, 2016 at 8:29 am

[...] problems to unsolved problems, is certainly an important aspect of

[Solving mathematical problems | nguyen Huynh Huy's Blog](#) mathematics, though definitely not the only one. Later in your research career, you will find that problems are mainly solved by knowledge (of your [...])

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21 July, 2017 at 2:47 am

Mathematics needs a lot of practice and clear concepts. One day while solving a

[Micheal Angelo](#)

problem I stuck badly and it took me an hour but could not solve the problem. Due to this stress my brain stopped working. Then I searched for online help and came across

Solutioninn to get some help from mathematics tutor. She explained me everything and helped me to solve that problem.

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20 August, 2017 at 9:11 am

[...]

[1 – “There's more to mathematics than grades and exams and methods” – Terence Tao](#) Source: <https://terrytao.wordpress.com/career-advice/there%E2%80%99s-more-to-mathematics-than-grades-and-exa…> [...]

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23 January, 2018 at 8:24 pm

[Có Nhiều Hơn là Sự Chặt Chẽ và Chứng Minh trong Toán Học | 5](#)

3/6/2018

There's more to mathematics than grades and exams and methods | What's new

[...] chứng minh” là nỗi sợ hãi của nhiều sinh viên ngành toán. (Đọc thêm “Có nhiều hơn là điểm số và thi cử và các phương pháp trong toán học“.) Nhưng việc chuyển giao từ giai đoạn hai sang ba cũng quan trọng không kém, [...]

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