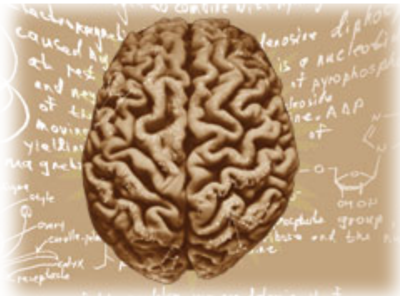

Science education mythbusters: Challenging the idea of expected grade distributions and ‘anomalous grades’

YORK UNIVERSITÉ UNIVERSITY

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Leading Edge

Commentary

Cell

A Wakeup Call for Science Faculty

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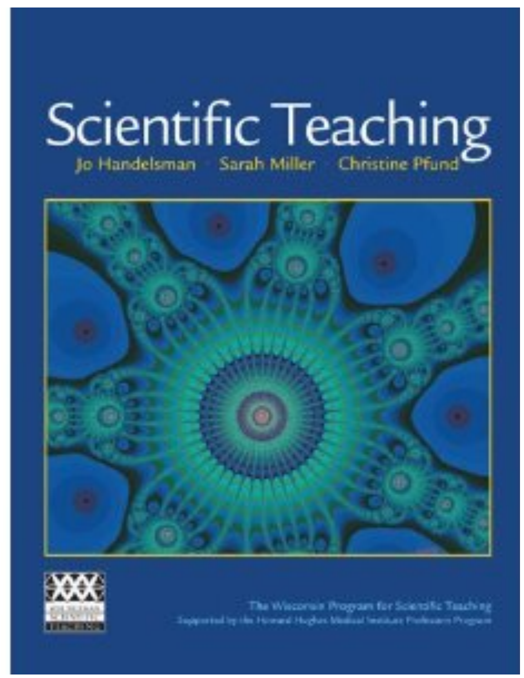
DOI: 10.1016/j.cell.2005.11.014

By changing the way we teach the introductory science courses in our colleges and universities, we can attract many more talented students to science careers. At the same time, we will be fostering positive public attitudes about science that are critical for a successful modern society.

UBC THE UNIVERSITY OF BRITISH COLUMBIA

CWSEI Carl Wieman Science Education Initiative at the University of British Columbia



Question 1:

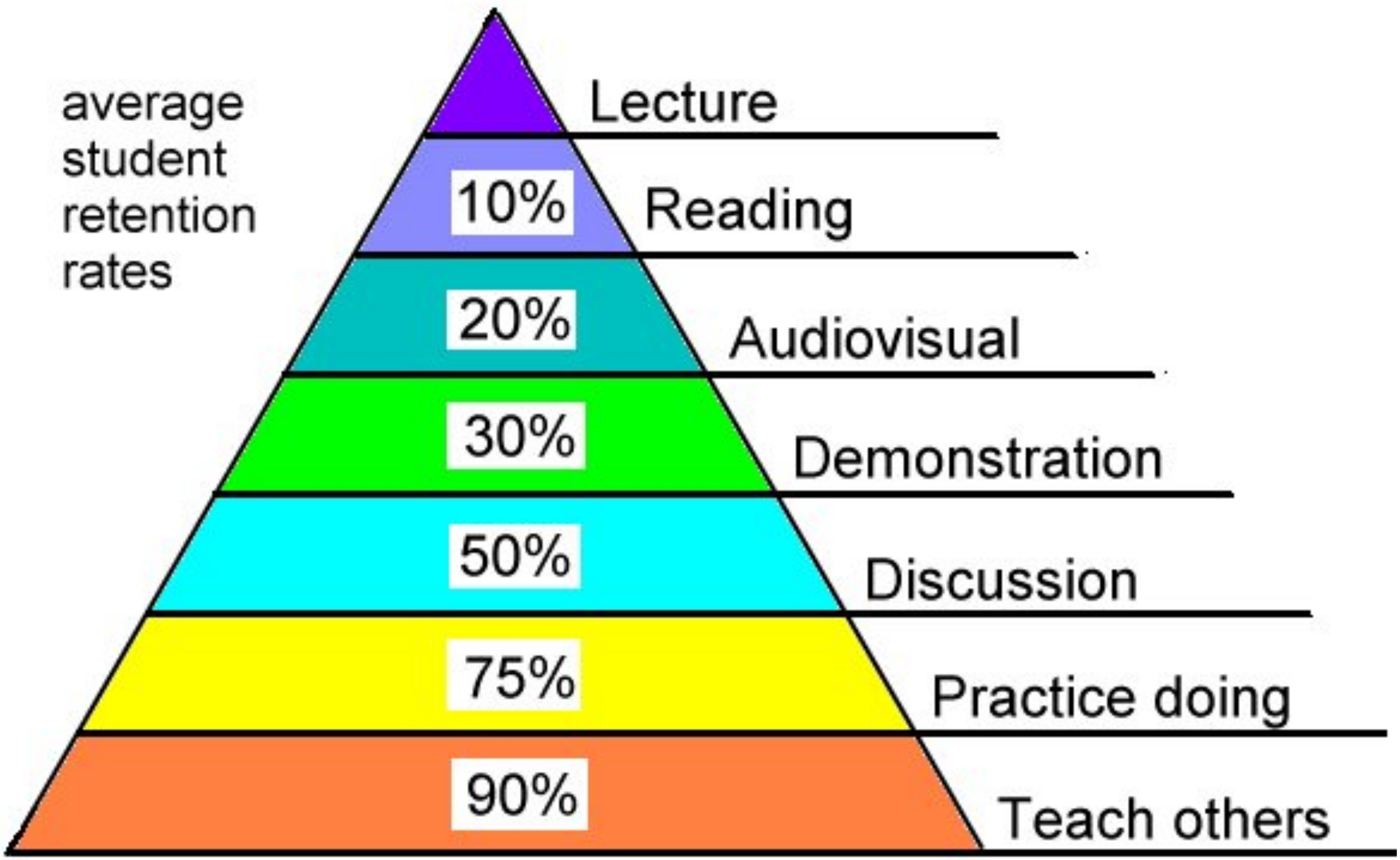
What are two preconceptions that non-experts have (re: topics/concepts in your discipline/ background)?

Key findings about learning (from cognitive science)

1. "Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom."

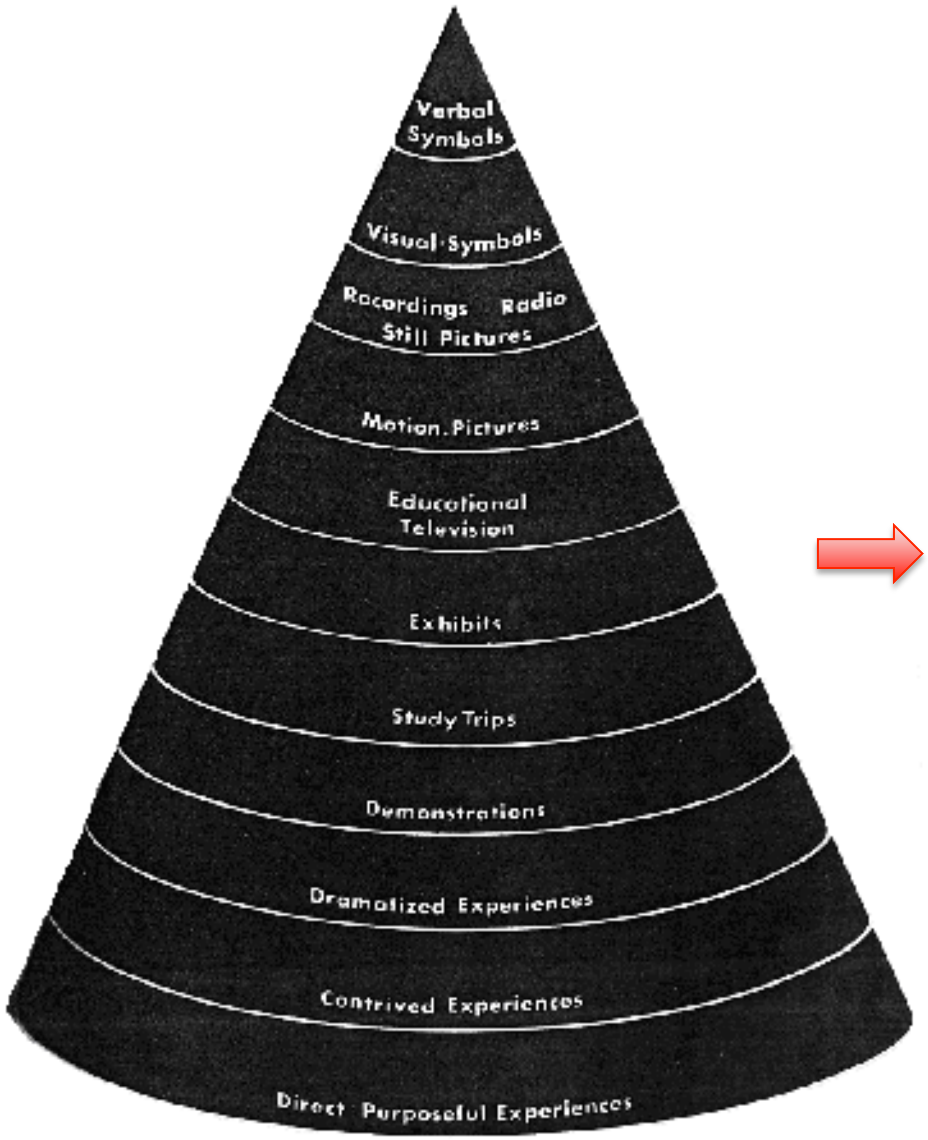
Commission on Behavioral and Social Sciences and Education (CBASSE), National Research Council. 1999. How People Learn: Bridging Research and Practice. The National Academies Press.

Learning Pyramid



Source: National Training Laboratories, Bethel, Maine

http://stephenslighthouse.com/2010/02/26/the-learning-pyramid/



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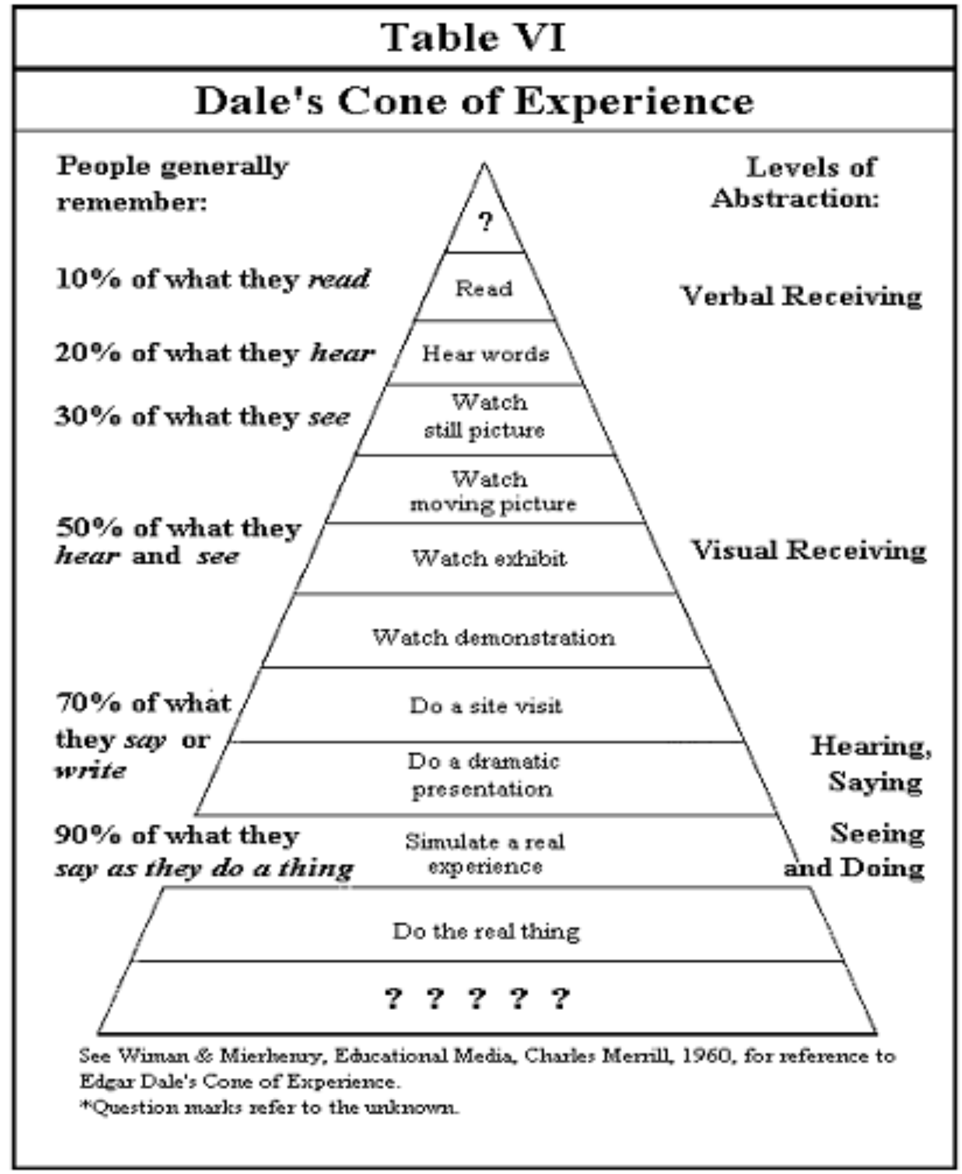

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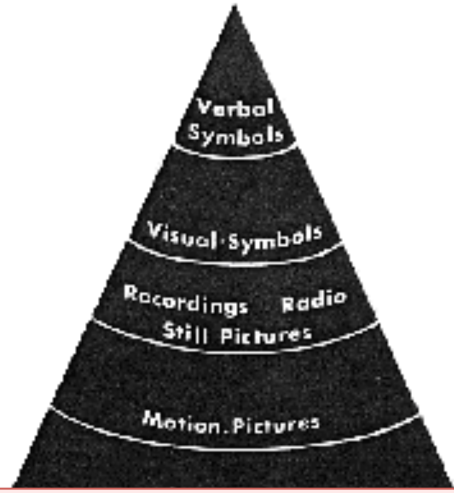
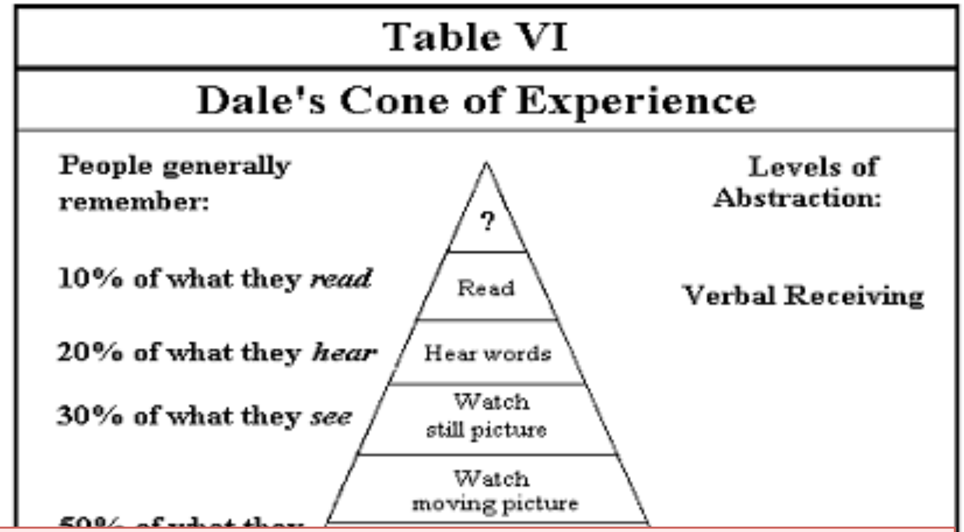




See
http://davidtjones.wordpress.com/2009/10/11/the-learning-pyramid-true-false-hoax-or-myth/
http://www.willatworklearning.com/2006/05/people_remember.html
http://schoolof.info/infomancy/?p=230

Lalley, J. and Miller, R. 2007. The learning pyramid: Does it point teachers in the right direction? Education and Information Technologies 128(1): 64-79.

Key findings about learning (from cognitive science)

1. "Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom."

Commission on Behavioral and Social Sciences and Education (CBASSE), National Research Council. 1999. How People Learn: Bridging Research and Practice. The National Academies Press.

Misconceptions, threshold concepts, concept inventories – Science Education (sampling):

Anderson, D.L., Fisher, K.M., and Norman, G.J. 2002. Development and evaluation of the Conceptual Inventory of Natural Selection.J. Res. Sci. Teach. 39: 952 -978.

Hestenes, D., Wells, M. and Swackhamer, G. 1992. Force Concept Inventory. The Physics Teacher 30: 141-151.

Klymkowsky M.W, Garvin-Doxas K, Zeilik M. 2003. Bioliteracy and teaching efficacy: what biologists can learn from physicists. Cell Biol. Educ. 2:155–161.

Tanner, K., and Allen, D. 2005. Approaches to Biology Teaching and Learning: Understanding the Wrong Answers--Teaching toward Conceptual Change. Cell Biol Educ 4: 112-117.

Question 2:

Would it be possible for each student in your class to earn an "A"?

Some assertions re: grade distributions

- There is an **expected** (or ideal) grade distribution for courses. (Also, or alternatively, there is an ideal average for a course.)
- Deviations from expected grade distributions are indicative of problems.
- Science courses are "harder" than non-science courses, which should be reflected in grade distributions.

Grade inflation ‘matters, Rojstaczer said, because "*the alternative is a student body that frequently misses class, never prepares in advance, studies about 11 hours a week if they are 'full time' students, and drinks itself into a constant stupor out of boredom. That's not an acceptable alternative anywhere.*" ‘

http://www.insidehighered.com/news/2009/03/12/grades

Rojstaczer is a retired Duke professor who created http://gradeinflation.com/

"Grade inflation got started ... in the late '60s and early '70s.... The grades that faculty members now give ... deserve to be a scandal."

--Professor Harvey Mansfield, Harvard University, 2001

"Grades A and B are sometimes given too readily -- Grade A for work of no very high merit, and Grade B for work not far above mediocrity. ... One of the chief obstacles to raising the standards of the degree is the readiness with which insincere students gain passable grades by sham work."

--Report of the Committee on Raising the Standard, Harvard University, **1894**

Kohn, A. 2002.

Alberta prof asked to resign over grades dispute

By Sarah Petz | December 31st, 2010 | 1:54 pm

Legal action threatened after students' marks lowered by admin

A University of Alberta math professor is threatening legal action to reinstate his students' grades after his department lowered them without his support. When Mikhail Kovalyov informed his students what had happened, and encouraged them to appeal their grades, he was asked to resign.

Back in May, Kovalyov received an email from an associate chair in the Department of Mathematical and Statistical Sciences informing him that grades for his first year math course had been lowered, resulting in a change in class average from 2.16 to 1.79 on a 4.0 scale. Other sections of the same course had averages that ranged from 2.13 to 2.95, according to documentation obtained by Maclean's. The math professor says that he had already failed over 20 per cent of the class before these changes were approved.

University guidelines suggest an approximate mean average of 2.62 for first-year courses, with only six per cent of the class failing.

When faculty services officer David McNeil, who is also responsible for reviewing final grade

http://oncampus.macleans.ca/education/2010/12/31/alberta-prof-asked-to-resign-over-grades-dispute/

Grade distribution not what you expected? Curve it!

Norm-referenced assessment (curve)

Underlying assumption that student performance will be distributed in a normal (or known) distribution.

- Provides consistency from session to session in grade distributions.
- Easy ranking of students (in cohort).
- Known problems with smaller groups (see Yorke 2008).
- Can foster competition.
- Does not necessarily reflect actual knowledge/performance, fair assessment.

Criterion-referenced assessment

Uses the extent to which the student has demonstrated achievement of the specified learning outcomes as the basis of evaluation.

- Independent of ability/ performance of other students in cohort.
- Transparent assessment.
- Requires appropriate learning outcomes, assessments.

To curve or not to curve?

Norm-referenced assessment (curve)

Underlying assumption that student performance will be distributed in a normal (or known) distribution

How is "expected" distribution determined?

What about the students who drop the course? (Are they factored in the expected distribution?)

Transparency – students must be informed that grades will be curved.

Fairness – how can students reflect on performance if interim marks may not align with final grade?

Expected by stakeholders (in some situations).

Cohort information – any way to know if differences in a particular session?

Criterion-referenced assessment

Uses the extent to which the student has demonstrated achievement of the specified learning outcomes as the basis of evaluation.

Appropriate learning outcomes must be developed.

Appropriate assessments for learning outcomes must be used in grading.

Loss of consistency from year to year?

Should provide better idea of which outcomes student has mastered (for employers, professional schools, etc.).

Supports grade integrity

"It is not a symbol of rigor to have grades fall into a 'normal' distribution; rather, it is a symbol of failure -- failure to teach well, failure to test well, and failure to have any influence at all on the intellectual lives of students."

-- Milton et al. (1986)

“Perhaps more important, grading “on the curve” communicates nothing about what students have learned or are able to do.”

“Students who receive the high grades might actually have performed very poorly but simply less poorly than their classmates.”

-- Guskey and Bailey (2001)

“Dysfunctional illusions of rigor”:

1. **Hard courses weed out weak students: when students fail it is due mainly to inability, weak preparation or lack of effort.**
2. A good clear argument in plain English can be understood by any bright student who applies herself.
3. Traditional methods of instruction provide proven effective ways of teaching content to undergraduates. Modes which pamper students teach less content.
4. If we cover more content, the students will learn more.
5. Traditional methods of instruction are fair to a wide range of diverse students of good ability.
6. Students should come to us knowing how to read and write and do essay and multiple choice questions.
7. It is essential that students hand in papers on time and take exams on time. Giving them flexibility and second chances is pampering them.
8. Classroom instruction is demonstrably better than distance education.

From: Nelson, C.E. 2007. How We Defeat Ourselves: Dysfunctional Illusions of Rigor (Key Lessons From The Scholarship of Teaching & Learning). The University of Windsor and Oakland University in Michigan First Annual Conference on Teaching and Learning May 7-8 2007.

Grade integrity

Sadler (2009) describes grade integrity as "*the extent to which grades are strictly commensurate with the quality, breadth and depth of students' academic achievement*."

He suggests several major threats to grade integrity, including: random error, bias, contamination of the object to be graded, and inappropriate grading principle.

Presumably, violating grade integrity could lead to grade inflation, and grade disparity.

Are science courses harder?

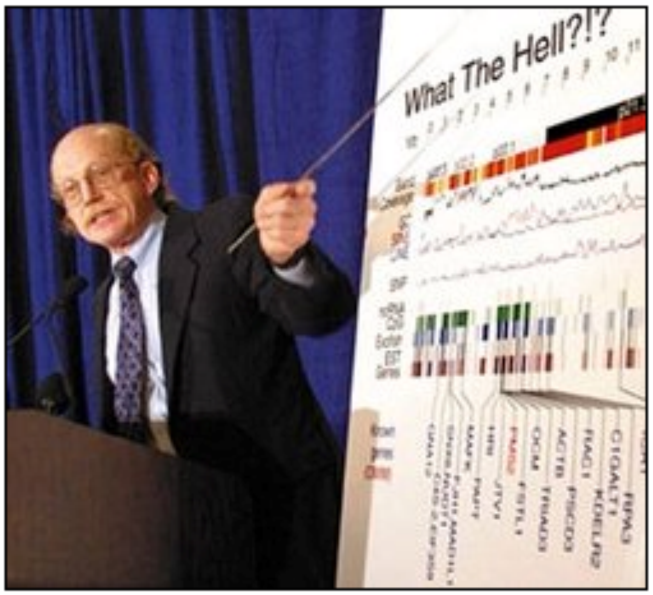
NEWS

National Science Foundation: Science Hard

JUNE 5, 2002 | ISSUE 45•01 ISSUE 38•21

INDIANAPOLIS—The National Science Foundation's annual symposium concluded Monday, with the 1,500 scientists in attendance reaching the consensus that science is hard.

Enlarge Image



Farian explains the NSF findings.

"For centuries, we have embraced the pursuit of scientific knowledge as one of the noblest and worthiest of human endeavors, one leading to the enrichment of mankind both today and for future generations," said keynote speaker and NSF chairman Louis Farian. "However, a breakthrough discovery is challenging our long-held perceptions about our discipline—the discovery that science is really, really hard."

"My area of expertise is the totally impossible science of particle physics," Farian continued, "but, indeed, this newly discovered 'Law of Difficulty' holds true for all branches of science, from astronomy to molecular biology and everything in be[...]n."

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http://www.theonion.com/articles/national-science-foundation-science-hard,1405/

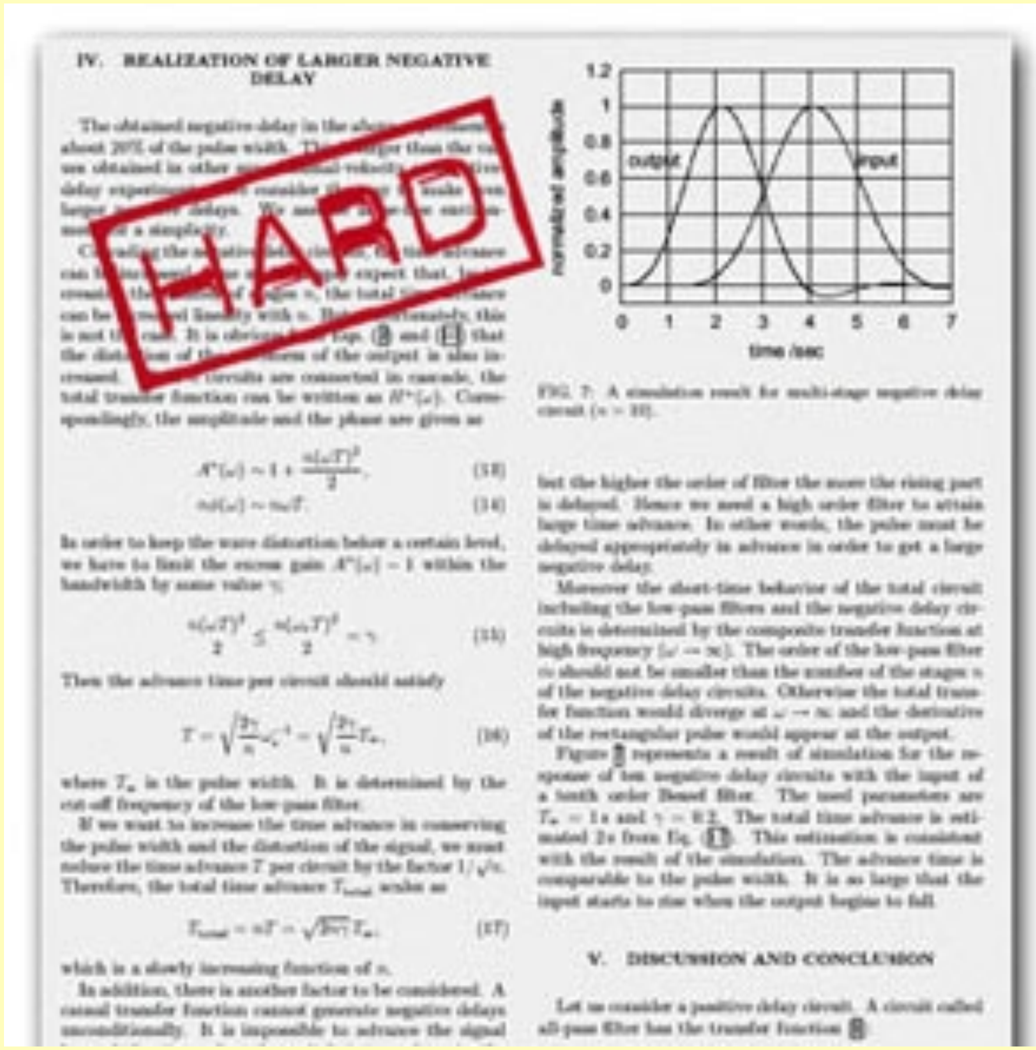
Mean Grades and Variances in Seven Universities, 1973-74 and 1993-94

Departments	*1973-74*		*1993-94*		*Number of University Courses*	*Inflation**	*Deflation**	*No Change**
	GPA	*Variance*	*GPA*	*Variance*				
English	2.17	1.04	2.76	0.89	6	6	0	0
French	2.47	1.15	2.69	1.07	7	4	0	3
Music	2.89	0.95	3.02	1.16	4	2	1	1
Philosophy	2.38	1.15	2.54	1.07	7	4	1	2
Biology	2.18	1.19	2.52	1.19	7	5	1	1
Chemistry	1.88	1.57	2.18	1.51	7	4	1	2
Mathematics	2.14	2.00	2.19	1.86	7	2	1	4
Physics	2.17	1.65	2.38	1.63	7	4	1	2
Economics	2.07	1.53	2.18	1.44	7	3	1	3
Political Science	2.37	0.90	2.49	0.94	7	3	1	3
Psychology	2.31	1.16	2.40	1.17	7	3	2	2
Sociology	2.57	1.02	2.51	0.92	7	2	3	2
Totals					80	42	13	25

Note: *10 percent level of significance. The means and variances for each of the 80 university courses were generated for the two reference years. Standard t-statistics for differences in means were calculated for each of the 80 pairings.

Table 1 in Anglin and Meng (2000). The authors gathered data from Ontario universities (Brock, Guelph, McMaster, Ottawa, Trent, Laurier and Windsor) in introductory courses for reference years 1973-1974 and 1993-1994.

Question 3:
What other factors (if any) might lead to lower grades in science courses?



http://www.theonion.com/articles/national-science-foundation-science-hard,1405/

Remaining questions/directions

- How can we assess quality (of students, of courses) beyond looking at grade distributions?
- How can we use assessments most effectively in science education?
- What effects are expected grade distributions having on students and faculty in higher education?
- Do we expect a shift in grade distributions with improved teaching/learning strategies?
- How can we have evidence-based discussions with colleagues, administrators to improve grade-related policies and practises?