What Matters in Education?

Thoughts from mathematics education research and my twenty years as an educator

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Background

B.S. Mathematics (Ohio State University)
M.S. Mathematics (University of Utah)
Ph.D. Mathematics and Science Education Research (UCSD/SDSU)

Private and public
Boarding schools and day schools
"Gifted" and "non-gifted"
STEM and non-STEM schools
Very small (< 5) to very large (> 200) classes
Online and in-person
Coed and single-sex
West coast, Middle America, East Coast
Middle school, high school, undergrad, grad, PhD

The First Question to Ask Yourself...

What change(s) do I want to facilitate in my class?

Some possibilities:

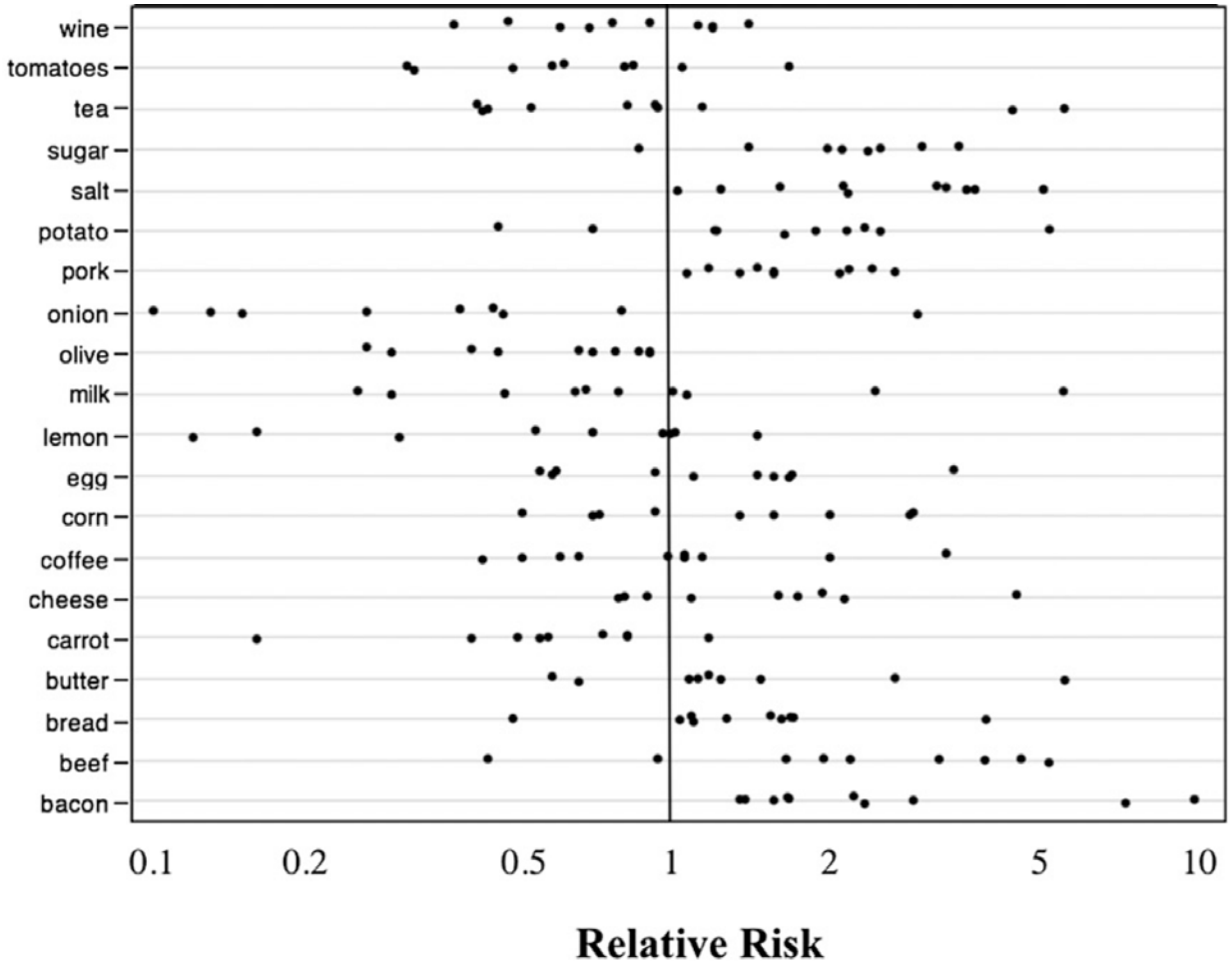
- Increased learning/understanding
- Increased love of mathematics
- Improved problem-solving skills
- Greater algebraic fluency
- Deeper conceptual understanding
- Increased belief in oneself
- Clearer view of mathematics in applied settings
- Realization of math as a tool for social justice

How will you measure this?

- Exam scores
- Homework sets
- CAPE scores
- Standardized tests
- Surveys
- Success in future math classes
- Success in non-math classes
- Drop-out rates

So, What Does The Research Say?

Education research, like food science research, is complicated because it has so many moving pieces. The "truth" is not found in a single research paper.



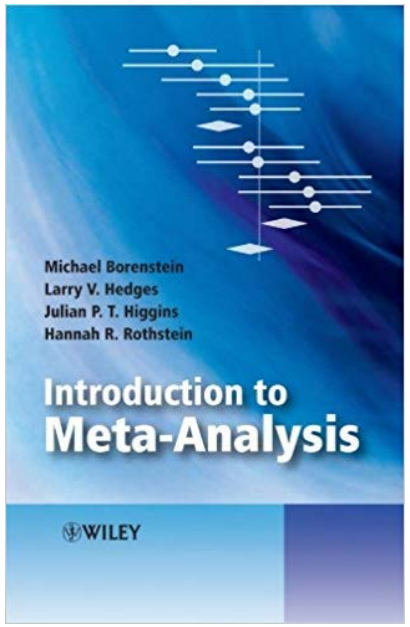
Here, each dot represents a study that measures how the consumption of a given food increases or decreases your risk of getting cancer. A relative risk above 1 means the food makes you more likely to get cancer.

Identify those foods where you think the evidence is still inconclusive.

From Schoenfeld and Ioannidis

Meta-Analysis

Meta-analysis is the analysis of analyses (the study of studies). It combines the results of several studies into one value (effect size), leveraging the results, sample sizes, and variability seen in the studies.



Source

Change desired: Improved enjoyment of math via teacher avoidance of shaming language ("obvious", "trivial", "should be clear")

Measure: Student self-reports before and after language change

Study 1	Study 2	Study 3
Enjoyment raised 3 points (0 – 100 scale), n = 120, SD of changes = 4 points	20% growth in students claiming to enjoy math (on yes/no scale), n = 32	Enjoyment raised 4 points (0 – 10 scale), n = 50, SD of changes = 5 points

Meta-analysis can combine results with disparate scales into a single effect size (roughly: the number of SDs of change, weighted across different settings)

Your Turn: The Sorting Hat, Round 1

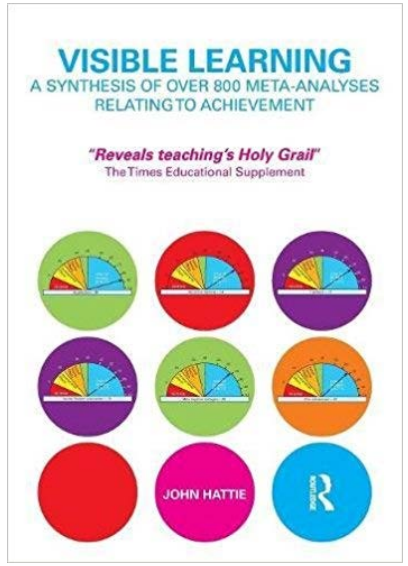
Below are 8 educational interventions/ideas. For each, guess the effect size the idea has on *achievement* (as measured by student course grades): this would be the end result of a meta-analysis of hundreds of articles about the intervention spanning many countries, ages, etc. Then sort from smallest to biggest. Work alone or in a group of two. Good luck!

1) Having college students live on campus vs. off
2) Supportive, intellectually-engaging home environment vs. not
3) Spacing out homework vs. giving same amount of homework in big chunks
4) Having a school environment of bullying vs. non-bullying environment
5) Allowing acceleration for stronger students vs. no acceleration allowed
6) Access to drugs for medical conditions (e.g. ADHD) vs. no access
7) Participation in extra-curricular activities vs. not
8) Interventions to teach study skills vs. not

An effect size of $d = 1.0 \iff$ increase in 1 SD of outcome measure $\iff$ about 2-3 years of academic growth $\iff$ correlation with achievement of $r \approx 0.50$

The Results Are In!

John Hattie:
Visible Learning (2009)



Hattie's meta-analytic *d* value	Micro Area
0.05	Having college students live on campus vs. off
0.57	Supportive, intellectually-engaging home environment vs. not
0.71	Spacing out homework vs. giving same amount of homework in big chunks
-0.22	Having a school environment of bullying vs. non-bullying environment
0.88	Allowing acceleration for stronger students vs. no acceleration allowed
0.33	Access to drugs for medical conditions (e.g. ADHD) vs. no access
0.17	Participation in extra-curricular activities vs. not
0.59	Interventions to teach study skills vs. not

What is interesting/surprising in these results?

Your Turn: The Sorting Hat, Round 2

Below are 8 "micro areas". For each, guess the effect size the micro area has on *achievement*: this would be the d in a meta-analysis of hundreds of articles about the micro-area spanning many countries, ages, etc. Then sort from smallest to biggest. Work alone or in a group of two. Good luck!

1) Desegregating students by race vs. segregating students by race
2) Changing school or residence from one school year to the next (mobility) vs. not
3) Having a summer vacation vs. not
4) Teaching students meta-cognitive strategies vs. not
5) Reducing class sizes vs. maintaining current (larger) class sizes
6) Analyzing the effectiveness of curricula (formative evaluation) vs. not
7) Having strong motivation to learn a subject vs. weak motivation
8) Interventions to improve students' diets vs. not

An effect size of $d = 1.0 \iff$ increase in 1 SD of outcome measure $\iff$ about 2-3 years of academic growth $\iff$ correlation with achievement of $r \approx 0.50$

The Results Are In!

Hattie's meta-analytic *d* value	Micro Area
0.28	Desegregating students by race vs. segregating students by race
-0.34	Changing school or residence from one school year to the next (mobility) vs. not
-0.12	Having a summer vacation vs. not
0.69	Teaching students meta-cognitive strategies vs. not
0.21	Reducing class sizes vs. maintaining current (large) class sizes
0.9	Analyzing the effectiveness of curricula (formative evaluation) vs. not
0.48	Having strong motivation to learn a subject vs. weak motivation
0.12	Interventions to improve students' diet vs. not

What is interesting/surprising in these results?

Bringing It All Together

We could collect all the meta-analytic *d*s from all the different interventions, ideas, theories, etc. in education and dump them into a histogram:

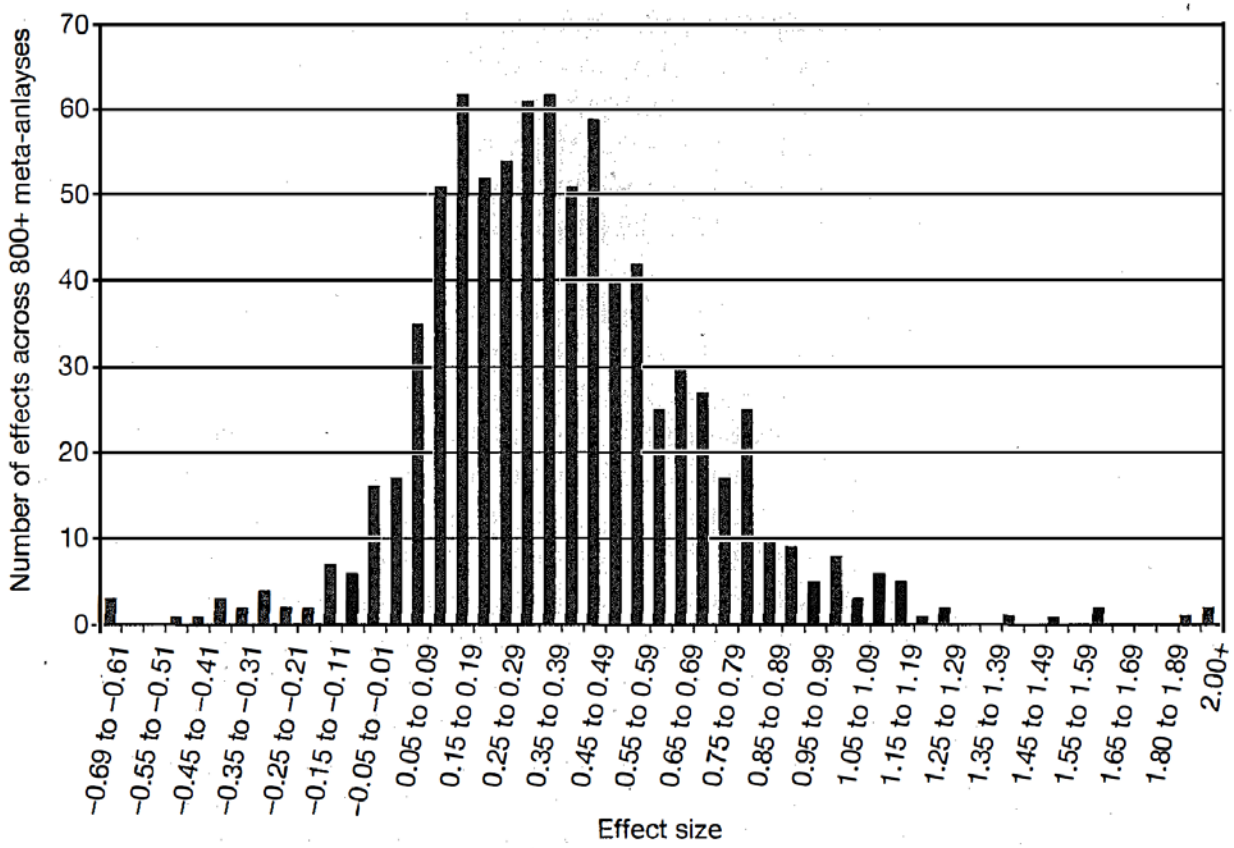


Figure 2.2 Distribution of effect sizes across all meta-analyses

Your Turn!

Make three observations from this histogram that have impacts on our behavior as teachers and researchers.

From Hattie's book Visible Learning (p. 16)

Some of Hattie's Observations

1. The distribution is normal. This is not obvious before you see the distribution. This also suggests that extreme effects are hard to create (good or bad!).

2. "Almost everything works. Ninety percent of all effect sizes in education are positive" (p. 15). Of the negative ones, half are expected (bullying, mobility, etc.) and could be revoiced as positive effects (non-bullying has a positive effect). Thus 95% of all interventions are positive.

3. (!!!) Doing a study and getting a $d > 0$ is basically meaningless. The bar should be $d > 0.40$, not $d > 0$.

So, What Matters Most in Education?

Read the 2015 article
(with updated effect sizes)

Rank	Influence	ES
1	Teacher estimates of achievement	1.62
2	Collective teacher efficacy	1.57
3	Self-reported grades	1.33
4	Piagetian programs	1.28
5	Conceptual change programs	1.16
6	Response to intervention	1.07
7	Teacher credibility	0.90
8	Micro teaching	0.88
9	Cognitive task analysis	0.87
10	Classroom discussion	0.82
11	Interventions for learning disable	0.77
12	Interventions for disabled	0.77
13	Teacher clarity	0.75
14	Reciprocal teaching	0.74
15	Feedback	0.73
16	Providing formative evaluation	0.68
17	Acceleration	0.68
18	Creativity programs	0.65
19	Self-questioning	0.64
20	Concept mapping	0.64
21	Problem solving teaching	0.63
22	Classroom behavioral	0.63
23	Prior achievement	0.63
24	Vocabulary programs	0.62
25	Time on Task	0.62
26	Not labeling students	0.61
27	Spaced vs. Mass Practice	0.60
28	Teaching strategies	0.60
29	Direct Instruction	0.60
30	Repeated Reading programs	0.60
31	Study skills	0.60
32	Pre-term birth weight	0.59
33	Spelling programs	0.58
34	Tactile stimulation programs	0.58
35	Service learning	0.58
36	CAI with learning needs students	0.57
37	Mastery learning	0.57

How often are students involved in the discussion of mathematical ideas? Is your classroom a monologue or dialogue?

Do students get *meaningful* feedback on their answers, solutions, presentation styles, in-class ideas? Do they give you feedback on your teaching?

Do you help students understand how to go about solving problems? Do you demand they frame the problem?

Do you participate in a once-a-week model for homework in mathematics classes or multiple times per week?

Personal Reflections: What I Find Matters the Most

1. Having an incredibly clear vision for your classroom and curriculum, and reinforcing this through every choice you make (see slide 3, consider every example/problem carefully)

2. Having incredibly high standards for student thinking and work (hardest problems that are still appropriate, demanding beautiful solutions instead of just answers, asking for thorough explanations, demanding proficiency across representational media)

3. Actually caring about students (avoiding shame/judgment, demanding accountability, demanding the most of yourself, recognizing differences in your path and their paths)

While the research literature can point to particular actions/interventions that one might take, these three suggestions are high-level dispositional stances.

4. Incorporating more active engagement in your classes (metaphors: musical instruments, sports)

Possibilities:

- Problems for students to work on individually
- Group-work for tasks that are appropriate
- Simple questions to the class with actual thinking times and distributing answers across the class
- Clicker/phone app technologies (Socrative)
- Students share solutions on the board (and perhaps talk through them)

You can find a list of 250+ active learning ideas here.

Thoughts, Questions, Comments? 

Takeaways:

Specific actions research supports:

1. Promoting class discussion
2. Giving detailed feedback to students and asking for it from students
3. Teaching problem solving
4. Spaced vs. mass practice

General dispositions I find valuable:

1. Clear vision and curriculum
2. High standards
3. Caring for students
4. Creating a practice room (active learning), not a recital (passive lecturing)

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