

Alternative Statistics Course: Statistical Literacy

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AAC&U Conference: *Transforming STEM*

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Slides: </pdf/2026-Schild-AACU-STEM-Slides.pdf>

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An Alternative Statistics Course: Abstract

Good news: STEM disciplines are in good shape with growing enrollments in computer science and biology.

Bad news: Social distrust of science among Republicans has increased from 14% (2020) to 34% (2024).

Problem: “Follow the science” has become political.

Causes: Can not distinguish hard science (experimental) from soft science (observational). Blind to confounding.

Solution: STEM needs to offer an intro course that focuses on the philosophy of science involving observational causation. This course is available. Students value it.

Good News: STEM Bachelor's Degrees Up

Number rose 44% between 2012 and 2021.

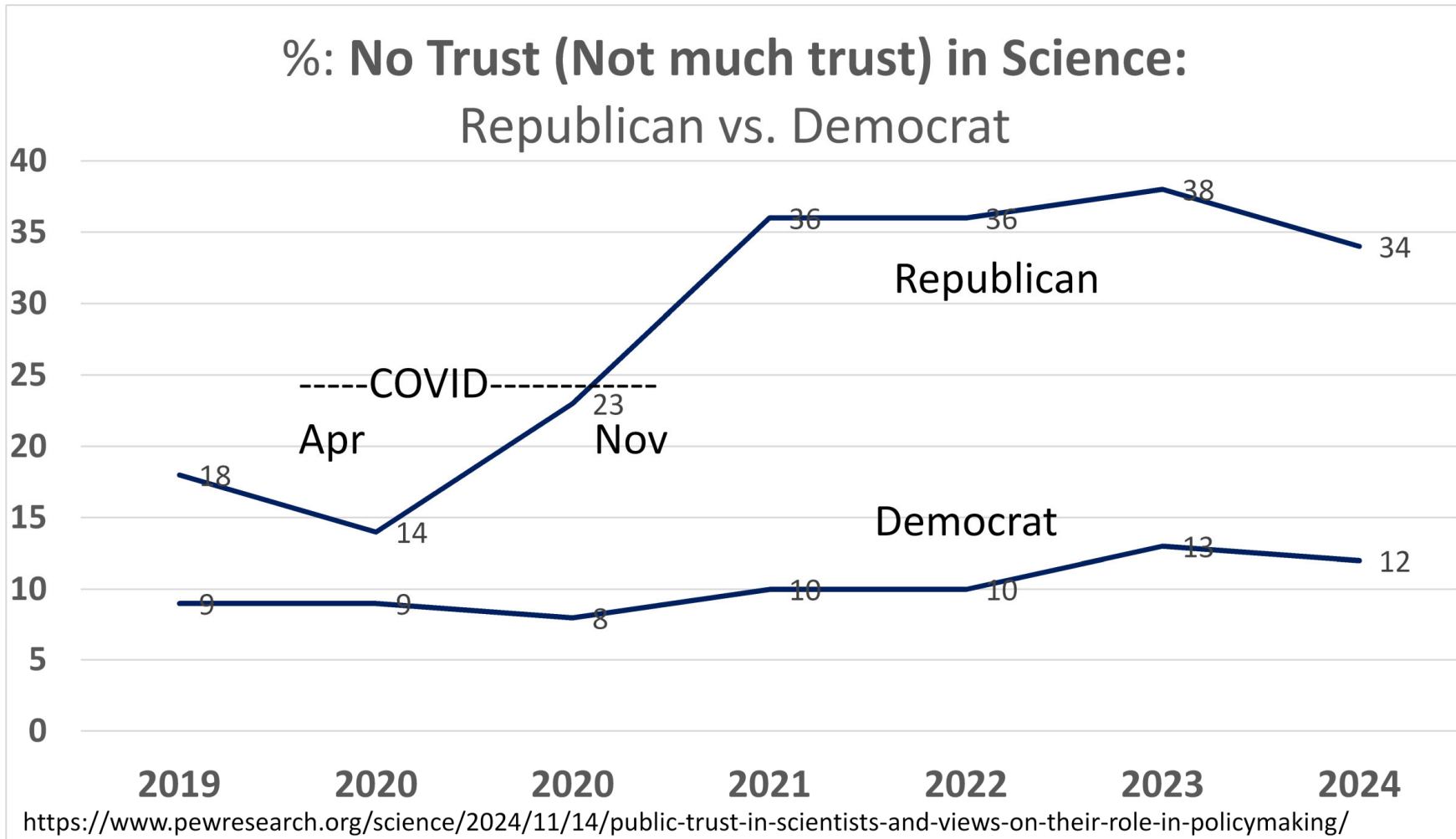
STEM grew from 16% of all degrees in 2012 to 21% in 2022, driven by growth in computer science and biology.

Table 322.10. Bachelor's degrees conferred by postsecondary institutions

Field of STEM study	1970-71	1990-91	2012-13	2020-21
Stem % of all Bachelor's Degrees	16%	16%	16%	21%
Total STEM	134,486	175,119	302,857	437,786
Biological and biomedical sciences	27%	23%	33%	30%
Computer and information sciences	2%	14%	17%	24%
Engineering	33%	36%	28%	29%
Engineering technologies\3\	4%	10%	6%	4%
Mathematics and statistics	18%	8%	7%	6%
Physical sciences and technologies	16%	9%	9%	7%

Source: https://nces.ed.gov/programs/digest/d23/tables/dt23_322.10.asp

STEM BAD NEWD: Distrust of Science



What happened with Covid?

2020 COVID School Closures: and Medical Goals

3/11: WHO declares Covid a “global pandemic”.

3/16: White House Covid Task Force guidelines:

“Governors should ‘close’ schools”

Spring break: Most states ‘close’ schools.

Covid medical goals:

- Minimize Covid cases,
- Minimize Covid deaths.

Could cases be cut in half without decreasing deaths?

Depends on what else deaths are related to.

COVID Death Rates: By Sex and Age

2/20/2020: Covid death rates based on WHO China data:

2.3% for 72K cases: 2.8% for men (1.7% for women)

- by age group:

- 15% for 80+ 8% for 70-79 4% for 60-69
- 1% for 50-59 0.4% for 40-49 0.1% for 10-39

Source: <https://statlit.org/pdf/2020-Schild-Covid19-Analysis-Slides-0308.pdf>

Conclusion:

Elderly (80+) are 15 times as likely to die as those age 50.

Elderly are 150 times as likely to die as those under 40.

COVID Policies: Reopenings

Businesses reopened quickly.

Schools stayed 'closed' (remote/hybrid) longer.

- Many districts stayed **remote or hybrid for months**.
- Some large districts (e.g., Los Angeles, Chicago, DC) did not reopen fully until **spring 2021**.
- Others (the Southeast) reopened **fall 2020**.

Republicans lost trust in science

“Follow the science”

Scientific authority used to justify sweeping policies

- closing businesses, closing schools, restricting groups.

Many of these policies involved **value judgments**.

Balancing epidemiology with:

- economic harm, educational loss and civil liberties.

These trade-offs were often presented as purely scientific decisions. Critics argued that **science was being used rhetorically to support political choices**.

How does This involve STEM?

Follow the Science!

- 1) *Choice of what to measure.* Suppose school closing prevented 20% of Covid cases (1% of Covid deaths). Would school closings be justified?
- 2) *Importance of study design.*
 - Covid vaccine tested **experimentally**: clinical trial.
 - School closure never tested; unknown effect on deaths.
- 3) *What to 'take into account' (control for).*
Minimal attention to age: controlling for age.

Controversial Issues

Consider some controversial issues and their disciplines:

- Climate change: Climatology/Atmospheric Science
- Environmental regulation. Environmental Science
- Vaccine side-effects: Pharmacovigilance/Medicine
- Systemic racism: Sociology & Social Psychology

These issues (disciplines) seem peripheral to STEM.

These Controversial Issues are Central to STEM

These controversial issues are *central to STEM* because:

- they use (are based on) the philosophy of science
- they involve statistics: everyday statistics.

STEM sets the standards for the philosophy of science. Philosophy of science focuses mainly on experiments: the gold standard for causation.

STEM needs an introductory course that focuses on the philosophy of science for observational causation.

STEM Needs Intro Course: Observational Causation

Consider the STEM disciplines that are observational:

- Epidemiology (public health),
- Geology and Earth Sciences,
- Astronomy and Astrophysics,
- Ecology and Evolutionary Biology.

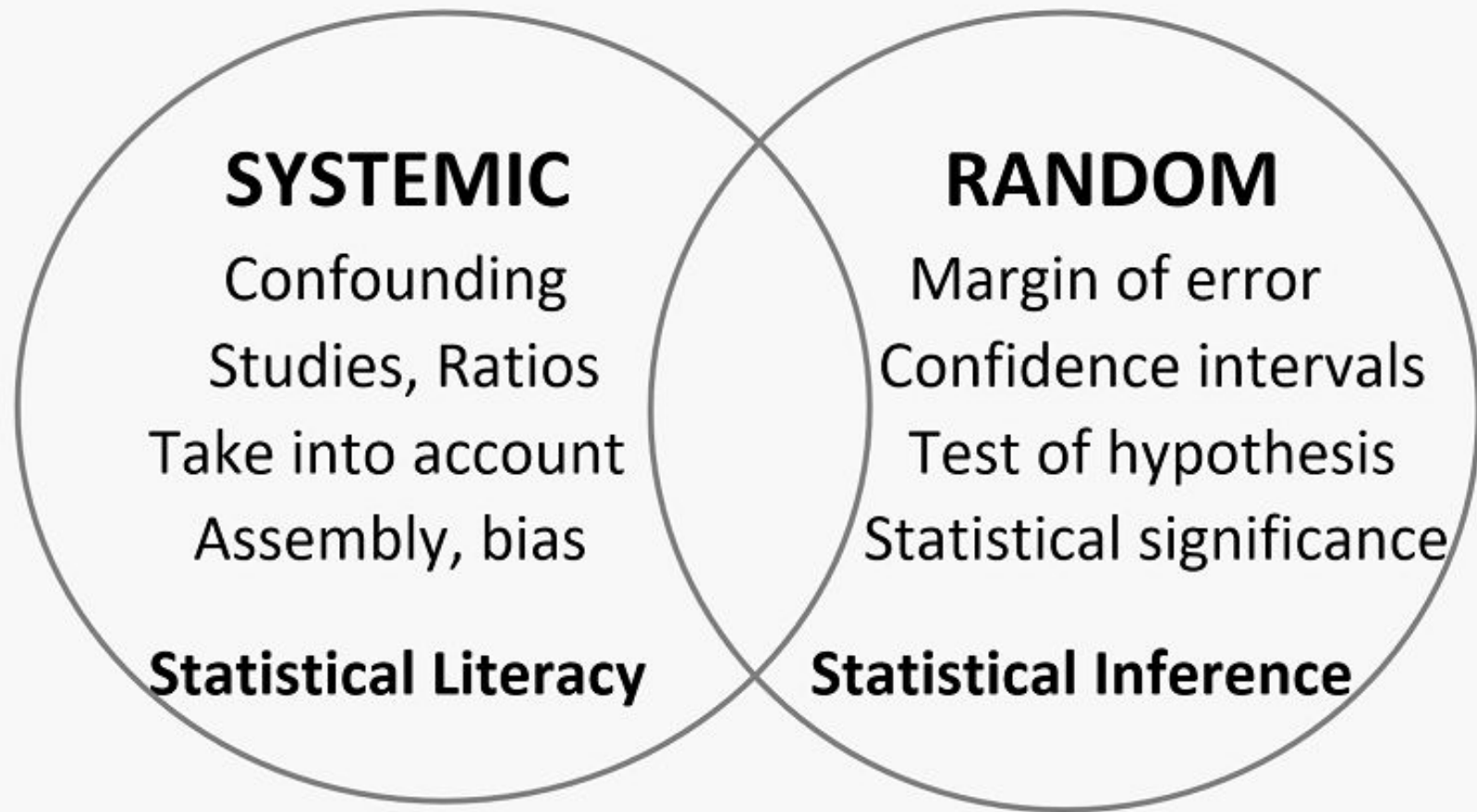
What journals deal with observational studies?

- *JAMA*: 30 to 40% of articles are observational
- *Journal of Econometrics*: perhaps 90%.
- *American Journal of Epidemiology*: perhaps 90%.

Statistical Literacy is an Alternative Statistics Course

STATISTICS STUDIES VARIATION

Two kinds of variation



Statistical Literacy: Statistical Foundations

1. Statistics are numbers in *context*.
2. Statistics are socially constructed by people.
3. Statistics can be influenced.
4. Best advice in using statistics: “*Take CARE*”.
5. The influences can be classified into four categories: Confounding, Assembly, Randomness & Error/bias. The first letters of each category spell CARE.

Statistical Literacy: Course Outcomes

1. Can distinguish association from causation (disparity from discrimination) in reality and words. Can use English to describe and compare ordinary statistics
2. Can identify and evaluate influences (confounding, assembly, randomness and error/bias) on a statistic.
3. Can take control of – or control for – these influences
 - Confounding: study design, select, ratios & standardize
 - Assembly: wording, data selection, comparison basis
 - Randomness: Law big numbers; statistical significance
 - Error/bias single and double-blind; random selection

Statistical Literacy: Course Outcomes

4. Can use ordinary English to describe and compare ratios presented in tables and graphs using percent, percentage, rate, and chance grammars.
5. Can evaluate the strength of evidence provided by statistics for arguments presented in the everyday media, in press releases and in journal articles.

College outcomes: All college graduates should (Schield, 2024)

- be able to distinguish disparity from discrimination,
- understand “controlling for something quantitatively”,
- be able to describe and compare rates and percentages.

Such a Course Exists: Statistical Literacy

Statistical literacy is “critical thinking about statistics”.

Statistical Literacy (Math 1300): Satisfies a math requirement in General Education at the U. of New Mexico where it is *required by all statistics majors*.

Statistical Literacy (Intro to Techne): *Required for all incoming students* at New College of Florida.

Textbook published by Kendall-Hunt in 2023.

<https://he.kendallhunt.com/product/statistical-literacy-2023-critical-thinking-about-everyday-statistics>

Such a Course Exists: *Statistical Literacy*

Statistical Literacy is different.

Less than a 30% overlap with traditional intro stats.

Students work multivariable problems without computers

Focuses more on

- *observational studies* than on experiments.
- *confounding* than on randomness
- *'taking into account'* than on statistical significance.
- *study design* than on deriving the standard error.
- *interpreting news stories* than on research articles.
- *using ordinary English* than on algebraic formula.

Is this a Math Course? Addresses Surprising Issues

Vaccinated covid cases are 2.4 times as likely to die as are unvaccinated cases.

Vaccines cause death? This seems implausible!

- Who did this study? British National Health Service.
- How many cases (deaths)? 268,000 cases; 730 deaths.
- What is associated with death? Comorbidities & age.

After ‘taking into account’ age (under 55 vs older), *unvaccinated covid cases are 3.4 times as likely to die as vaccinated cases.* Simpson’s paradox reversal.

Why? Elderly much more likely to be vaccinated.

Is this a Math Course?

Addresses Contemporary Issues

Separate disparity from discrimination. (Schield 2022b)

Work problems that control for confounders:

- Male-female income gap. Reduce gap by 32% by controlling for work status (FT permanent vs. other).
- Black-white family income gap (Reduce gap by 65% by controlling for single-parent versus married).

This course claims that statisticians have *no* professional expertise in whether a controversial disparity is caused by discrimination. Statisticians do have professional expertise in seeing how a disparity can be influenced.

Confounding is the Elephant in the Room

As observational data becomes more common, and as data sizes increase, confounding becomes more important than randomness or statistical significance.

Of 100 statistical textbooks, 80 had no reference to confounding in the index. Of the 20, most had a single example showing correlation is not causation.

None of the 20 showed students how to work problems controlling for confounding without computers or algebra.

Statistical Literacy: Student and STEM Benefits

Show students

- the power of the STEM disciplines as data based
- the beauty and power of mathematics,
- the power of quantitative thinking,
- *how to deal with controversial statistics.*

Possible STEM Benefits:

Might reduce dropout. Of those starting in STEM

45% don't graduate: 25% switch, 20% dropout.

STEM needs non-traditional minds:

Ramanujan in math; Hawking in physics.

Students value Statistical Literacy

Student Responses (agree)

This course helped my critical thinking. 80-90%

I would recommend this course to a friend. 70-80%

This course should be required for all students. 40-60%.

The latter is most significant when the students are in non-quantitative majors. Here is one student's comment:

“This is the first time I feel like I'd actually use a math class outside of the classroom regularly.”

See Schield (2022a).

Next Steps

AAC&U/PKAL should:

- support the need for an introductory STEM course that introduces students to statistical literacy,
- support the need for an alternative statistics course
- support member disciplines in asking statistics departments to offer courses like statistical literacy.

Most importantly, AAC&U/PKAL should develop:

- a VALUE rubric for courses like statistical literacy.

References

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Schiold CV

Fellow in the American Statistical Association.

PhD in Space Physics, Rice University.

- Physics: 6 papers, 500+ citations.
- Statistical Literacy: 120+ papers with 1,500+ citations.

Author of one textbook; co-author of a second.

Principal Investigator: \$500,000 award from the W. M. Keck Foundation to develop Statistical Literacy.

Named “the leader of the statistical literacy movement”
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Website: www.MiloSchiold.com

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Statistical Literacy: 2026 AACU STEM slides 1 V2

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Statistical Literacy: 2026 AACU STEM slides 2 V2

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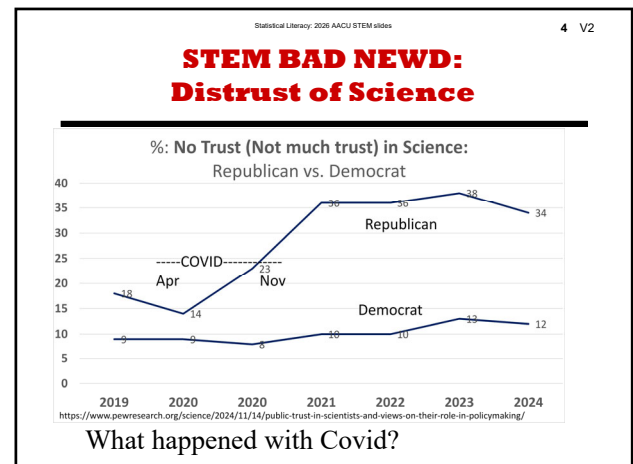
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Republicans lost trust in science "Follow the science"

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How does This involve STEM? Follow the Science!

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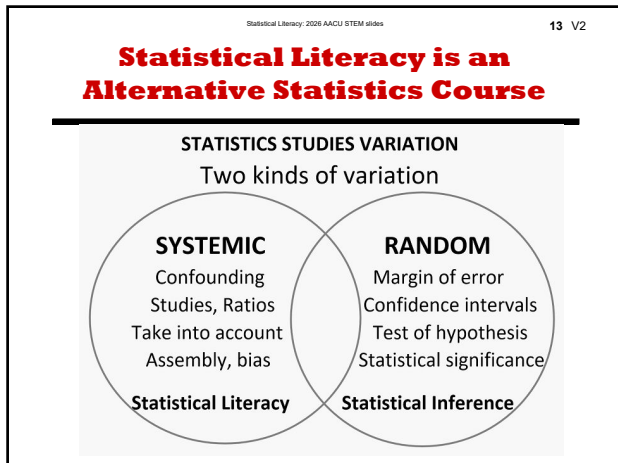
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Statistical Literacy: Statistical Foundations

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Statistical Literacy: Course Outcomes

4. Can use ordinary English to describe and compare ratios presented in tables and graphs using percent, percentage, rate, and chance grammars.
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College outcomes: All college graduates should (Schield, 2024)

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Statistical Literacy: 2026 AACU STEM slides 17 V2

Such a Course Exists: Statistical Literacy

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- *interpreting news stories* than on research articles.
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***Is this a Math Course?
Addresses Surprising Issues***

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Vaccines cause death? This seems implausible!

- Who did this study? British National Health Service.
- How many cases (deaths)? 268,000 cases; 730 deaths.
- What is associated with death? Comorbidities & age.

After 'taking into account' age (under 55 vs older), *unvaccinated covid cases are 3.4 times as likely to die as vaccinated cases.* Simpson's paradox reversal.
Why? Elderly much more likely to be vaccinated.

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Addresses Contemporary Issues***

Separate disparity from discrimination. (Schield 2022b)
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- Black-white family income gap (Reduce gap by 65% by controlling for single-parent versus married).

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Statistical Literacy: 2026 AACU STEM slides 21 V2

***Confounding is
the Elephant in the Room***

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***Statistical Literacy:
Student and STEM Benefits***

Show students

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- the power of quantitative thinking,
- *how to deal with controversial statistics.*

Possible STEM Benefits:
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45% don't graduate; 25% switch, 20% dropout.
STEM needs non-traditional minds:
Ramanujan in math; Hawking in physics.

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***Students value Statistical Literacy
Student Responses (agree)***

This course helped my critical thinking. 80-90%
I would recommend this course to a friend. 70-80%
This course should be required for all students. 40-60%.

The latter is most significant when the students are in non-quantitative majors. Here is one student's comment:

"This is the first time I feel like I'd actually use a math class outside of the classroom regularly."
See Schield (2022a).

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Next Steps

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Most importantly, AAC&U/PKAL should develop:

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Schild CV

Fellow in the American Statistical Association.
PhD in Space Physics, Rice University.

- Physics: 6 papers, 500+ citations.
- Statistical Literacy: 120+ papers with 1,500+ citations.

Author of one textbook; co-author of a second.

Principal Investigator: \$500,000 award from the W. M. Keck Foundation to develop Statistical Literacy.
Named “the leader of the statistical literacy movement” by Joel Best in *More Damned Lies and Statistics*.
Website: www.MiloSchild.com

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