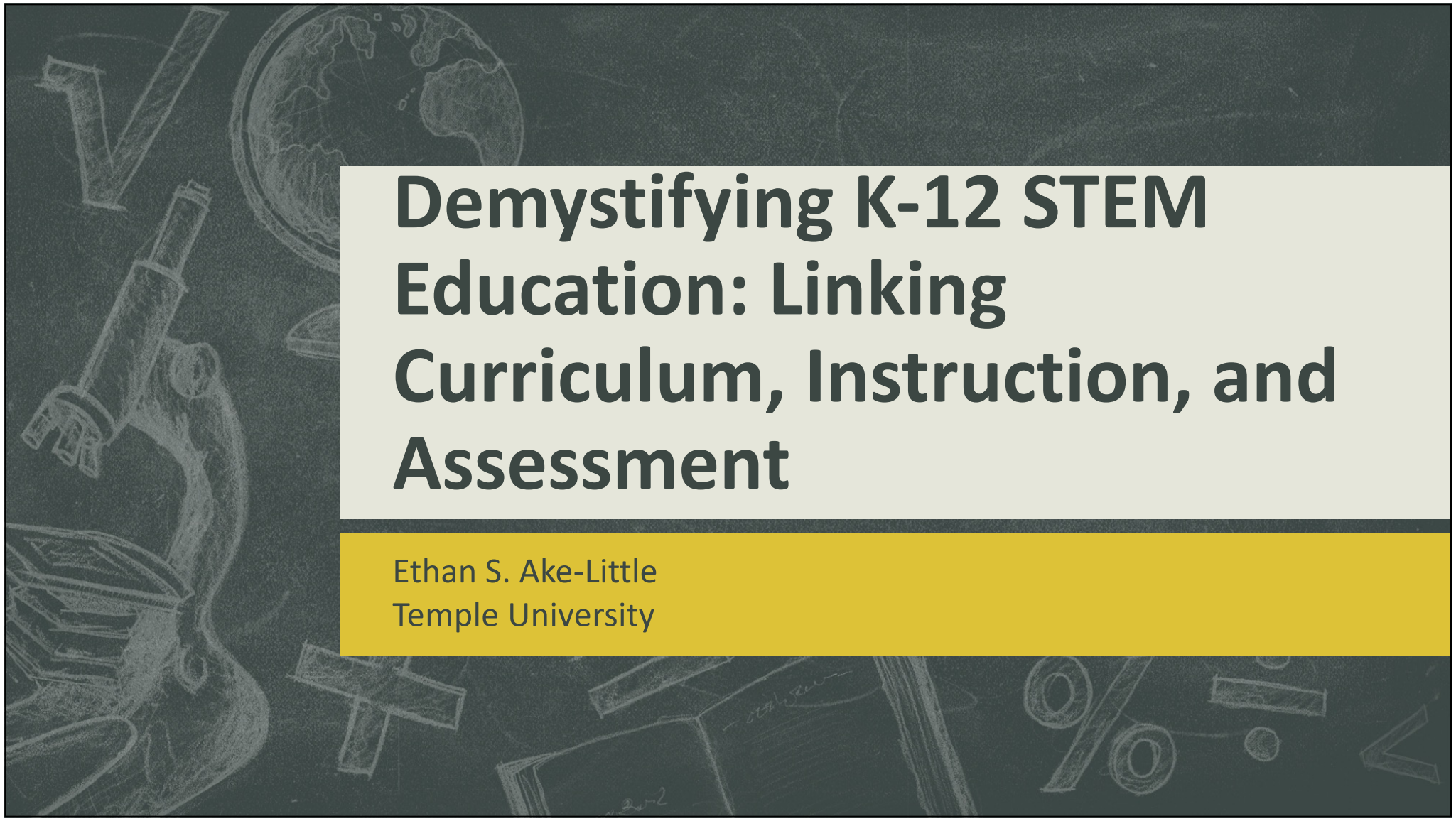

Demystifying K-12 STEM Education: Linking Curriculum, Instruction, and Assessment

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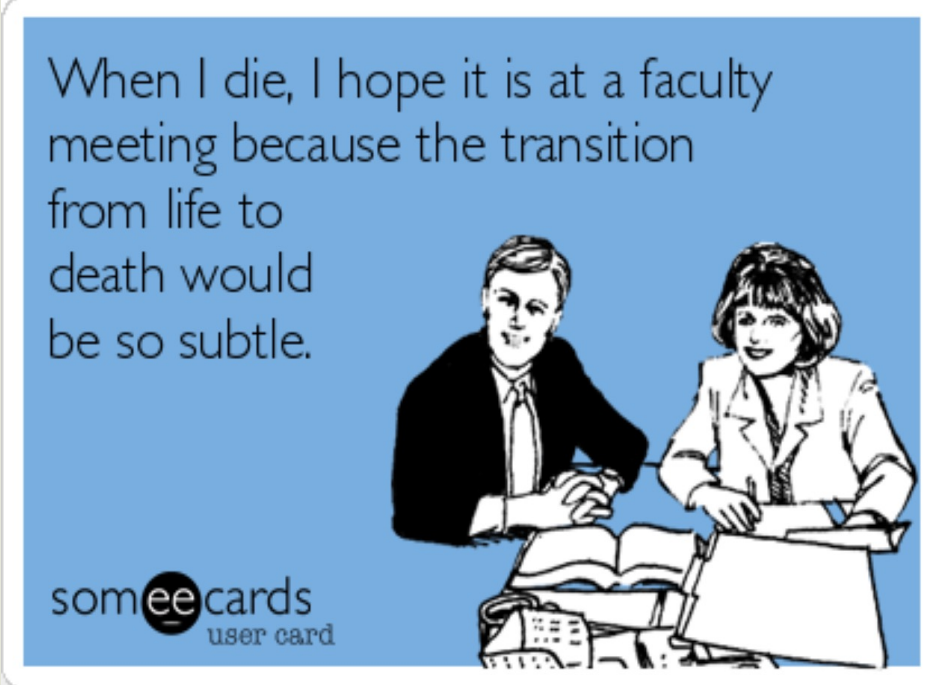
Presentation Goals & Agenda

Objectives

- ✓ Develop a better understanding of what STEM Education is and is NOT
- ✓ Discuss how a strong curricular and instructional backbone are the key to improved student outcomes in STEM
- ✓ Embrace assessment as means to improve STEM instruction
- ✓ How educational leaders (building or district level) can implement improvements in STEM programming

Presentation Agenda

- ➢ Introduction to the Presentation (5mins.)
- ➢ Myths and Facts about STEM Education (10mins.)
- ➢ Curriculum and Instruction in STEM Education: Primary, Secondary, and Diverse Learners (30mins.)
- ➢ Assessment & Accountability in STEM Education (15mins)
- ➢ Educational Leadership Matters in STEM Education (15mins.)
- ➢ Question & Answer Period (15mins.)

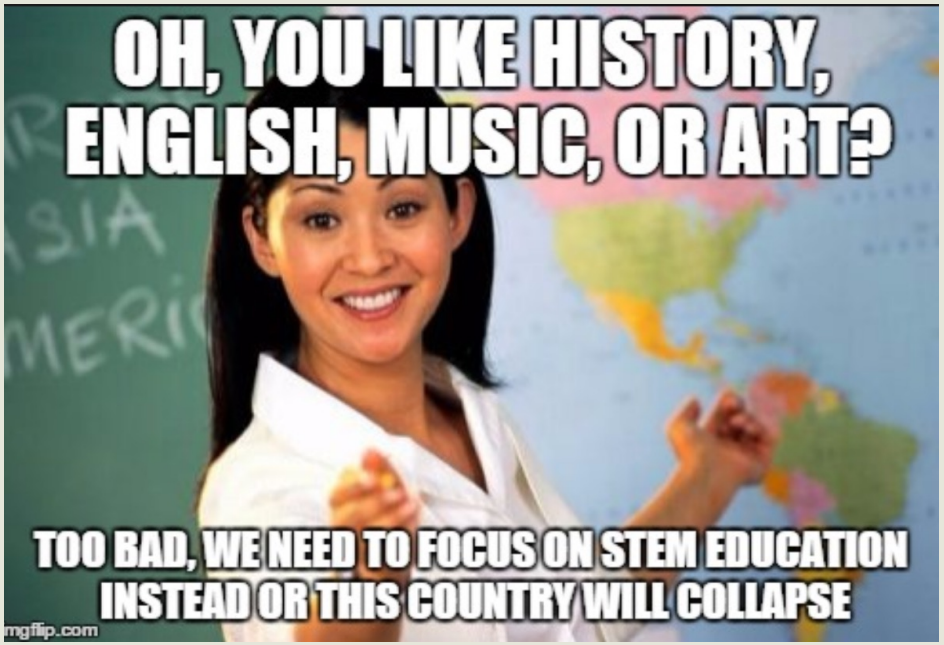


STEM, STEM, Everywhere…

As an educator, you are probably sick and tried of hearing about STEM (Science, Technology, Engineering, and Mathematics).

And it's not helping that everyone from the Bill & Melinda Gates Foundation to the National Science Foundation is handing out grants for researchers and administrators to find ways to improve STEM Education.

And it's getting worse! It looks like other subjects are hopping on the STEM bandwagon. There's now
STEAM ('A' for Arts)
STREAM (with an 'R' for Reading)
STEAMER (with another 'E' for entrepreneurship) [1]
Disclaimer: I made up the last acronym!



It's easy to feel both a sense of apprehension and being overwhelmed. So it's more important then ever that we separate myth from fact and focus on what on what this alphabet soup of letters is really hinting at – **a strong program that links curriculum, instruction, and assessment** both within and outside STEM subjects.

Myths and Facts About STEM Education

MYTH #1

The world is changing; there are more jobs in STEM than ever before. If I don't double-down in my STEM program, my students won't be competitive for post-secondary education or career options.

FACT #1:

You're right, the world is changing, but that doesn't mean you should "put all your eggs in one basket". Your students will be much better prepared for STEM and non-STEM jobs alike if they have a strong foundation in all core subjects. [2]

MYTH #2:

I don't really have a strong STEM background as a school administrator. I trust my STEM teachers know what they are doing and I leave them alone.

FACT #2:

They need your help too! In fact, one of the two major reasons teachers (especially in urban settings) leave is lack of administrative support. [3] Yes, content knowledge matters but you can learn. After all, you are expecting your students to master the material.

Myths and Facts About STEM Education (Continued)

MYTH #3

If I expose my students to "fun" STEM related experiences, that will inspire them to engage more in STEM related subjects.

FACT #3:

It's all fun and games until some gets (academically) hurt. Without any structured approach to STEM curriculum or instruction, the experience becomes frustrating for both students and teachers. [4] There is a reason why a Montessori approach to secondary education is rare.

MYTH #4:

If I don't invest in expensive resources like 3D printers and Maker-Spaces, I'm going to lose out to other schools who are making those investments.

FACT #4:

This "keeping up with the Joneses" approach is a surefire way to spend lots of time and money but get only marginal returns. It may be true that "if you build it, they will come", but keep in mind "that without a vision, the people will perish."

Curriculum & Instruction in STEM Education (Part I: Primary Level – K-6)

STEM in K-6?

The idea of STEM in K-6 brings up images of LEGOs/K'Nex, puzzles, and specialty STEM toys. This is a great way to engage primary students in STEM, but a commitment to strong STEM program has to go beyond STEM "playtime".

What skills are essential for STEM success in K-6?

Non-fiction Reading: Reading is an essential part of the K-6 curriculum, but there is an inordinate amount of emphasis put on fiction reading at the expense of non-fiction and/or technical reading (which is essential to STEM mastery).

Arithmetic: Working with numbers (again essential to STEM) requires students to become facile with measurement and calculations. (And yes, that means having students ditch the calculator and memorize multiplication tables.)

Curriculum & Instruction in STEM Education (Part I: Primary Level – K-6)

What about science courses?

Yes, having science courses (organized by theme or discipline) will introduce students to basic principles of science (e.g. cells, the environment, acid/bases, force, motion, etc.)

Many districts, especially those strapped for money, have taken away science courses in K-6 to focus on English Language Arts and Mathematics. **Don't fall into this trap!**

If you are doing this, you are setting your students up for failure well into the secondary years. **Students need classroom time to learn content which is essential in science courses.**

DO:

- Make opportunities available for primary school teachers to take general science classes. Research shows primary school teachers have serious apprehension about teaching math and science. **[5]**

- Push for more professional development that encourages teacher interdisciplinary learning in their classes. Interdisciplinary learning is much easier at the primary level since generally one teacher teaches all the core subjects. **[6]**

DON'T!

- Go out and buy every Chromebook, iPad, or coding website site license you can find. Many teachers feel obligated to use these tools just because they *have them* not because they *need them*. **[7]**

- Feel guilty about not exposing your students to fancy technology early in their primary years. Not only are they likely getting their fix at home, but more research is indicating that too much exposure to screen time in the early years can really hamper mental development. **[8]**

Curriculum & Instruction in STEM Education (Part II: Secondary Level – 7-12)

What skills are essential for STEM success in K-6?

Algebra: Many students (and adults) have difficulty with algebra because it is where logic, structure, and numbers all meet. But manipulating equations is essential for success in higher level STEM courses.

Content Knowledge: This one may seem obvious, but math and science courses are notorious for having a large number of concepts to cover in a relatively short time leading to an attenuated curriculum.

Reading Comprehension: As math and science courses becomes more intensive, students are bombarded with new terminology, nuanced theories and problem solving tasks. Research shows that reading comprehensive skills improve significantly when students have a stronger knowledge base. **[9]**

Curriculum & Instruction in STEM Education (Part II: Secondary Level – 7-12)

That sounds a lot easier said than done!

It is! But think of it this way, the strength of your science curriculum is a barometer for the strength of your core curriculum as a whole.

Vertical & Horizontal Alignment

Vertical alignment (VA) means that your coursework curriculum, scope, and sequence are arranged in such a way that by the time your students enroll in the your most senior courses, they have been exposed to the concepts covered in that courses to some degree.

Horizontal alignment (HA) means that your coursework *within* a grade level is interdisciplinary (i.e. each course draws upon the skills and ideally content from other courses).

Many schools already have a VA system in place, but the majority of schools are challenged by implementing HA. But it can be done!

Curriculum & Instruction in STEM Education (Part II: Secondary Level – 7-12)

Do I need to develop high level electives and coursework?

Only useful if you meet two criteria: (1) you feel confident in your students' and teachers' ability to engage in this work and (2) the coursework doesn't degenerate into "academic improv".

(1) AP courses are comprehensive and require mastering a range of topics. It is counterproductive to have a teacher or student teach or learn a course, respectively, in which they barely feel capable.

(2) High level electives should NOT be based on someone's pet cause/niche or have a narrow objective. Invariably, these courses will run out of material and resort to academic "improv".

DO:

- Encourage more VA in departmental meetings so that teachers can map curricula from 7th grade onwards. If you have some kind of senior STEM course such as AP Biology or AP Calculus (AB/BC), then ask teachers to engage in backwards design.
- Push for inter-departmental committees charged with HA implementation. Such committees would have faculty from at least all the core subjects they have some authority to suggest curricular changes. At the secondary level, departments are siloed so attempting to engage in interdisciplinary learning is a deliberate effort.

DON'T!

- Leave students to figure out content on their own. Teaching techniques like flipped classroom can have value. especially when reviewing previously taught concepts, but they cannot be a substitute for learning new material!
- Go on a spending spree with technology. Remember Google and Apple see you as a customer (with public funds). They are not the ones responsible for your students' academic outcomes. Make sure you know the *curricular* reason why you *need* to purchase this technology otherwise you will be conned.

Curriculum & Instruction in STEM Education (Part III: Diverse Learners)

Who are Diverse Learners?

- ✓ Historically Under-Represented Students (African-American, Hispanic, Native-American, etc.)
- ✓ Special Education Students (esp. Learning Disabled)
- ✓ English Language Learners
- ✓ In the case of STEM, women (all groups)

Why do they face challenges in STEM Education?

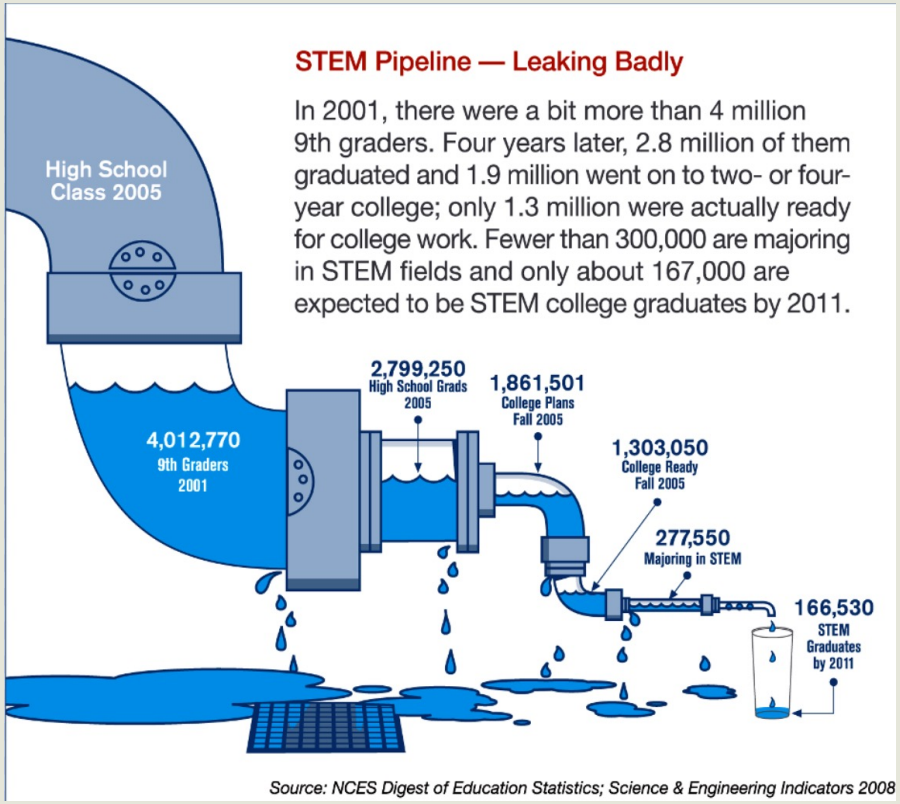
Recent research shows that while 71 percent of HUS succeeded on the assignments they were given, only 17 percent of those assignments were actually on grade level. But these students only fared slightly less well on the harder, grade-level assignments than their peers when given the chance. **[10]**

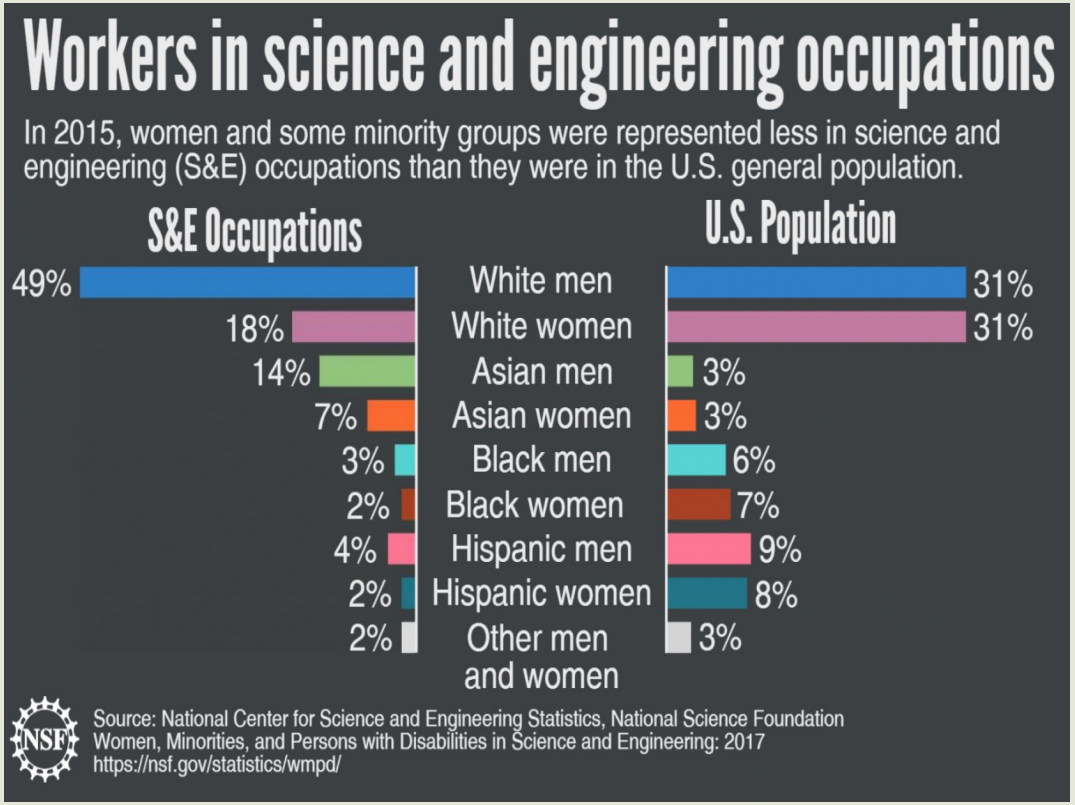
Special Education and ELL students likewise have a history of being placed in less rigorous environments both in terms of curriculum *and* instruction. **[11]**

Female students have internalized gender roles and believe STEM is for male students. **[12]**

If your science curriculum is a barometer of your school's curricular strength **and** *If* teaching diverse learners is a gauge of your school's instructional quality **then** **Improvements in academic outcomes for diverse learners is science (and more broadly STEM) courses IS the measure of your school's overall academic quality.**

The Sad State of STEM Demographics…





STEM Assessment
(Part I: Developing Internal Assessment)

Data Driven Instruction

- ✓ Attempting to improve instruction without attention to assessment is futile!
- ✓ Internal assessment need to be (1) mapped in conjunction with curriculum to ensure tight alignment between the two and (2) should be in a format that also aligns with major external assessments.
- ✓ Data driven instruction can face resistance from teachers, but administrators don't need buy in; the results are the buy-in. **[13]**

DO:

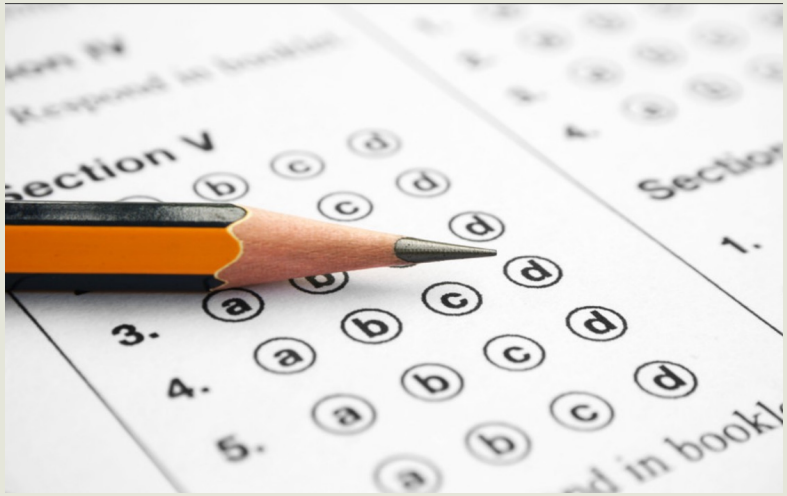
- ❖ Require periodic *common* assessment between teachers who teach the same subject.
- ❖ Encourage/make available data analysis related professional development for administrators and teachers.
- ❖ Provide teachers time (particularly on professional development days) to work within their departments or grades to analyze assessment results and modify instruction.

Examining assessment results at the end of the year is like attempting to diagnose a patient by performing an autopsy on a dead individual – **the damage is done and there isn't a second chance for the student.**

STEM Assessment
(Part II: Understanding External Assessment – Standardized Testing)

What are external assessments in STEM?

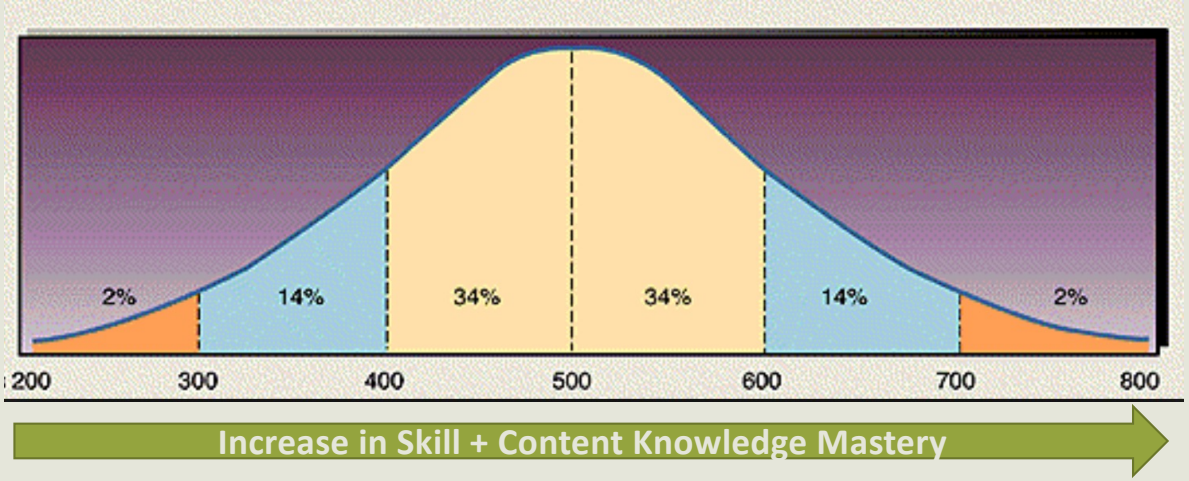
- State: PSSA Math/PSSA Science; Keystone Algebra I/Biology
- National: P/SAT Math, SAT Subject Tests, ACT Math/Science
- International: IB or AP Math/Science



How are standardized tests developed?

Standardized tests are developed using a process in statistics called norming (i.e. alignment to a perfect bell curve)

On aptitude tests (including IQ tests), the average score is considered the 50th percentile. But scores don't increase linearly. On the SAT Verbal, 4x drops score from 800 to 750, another 4x drops the score to 700, but then an additional 4x drops the score to 670. **[14]**



STEM Assessment
(Part III: External Assessments + Accountability)

SAT II Exam Name	Average Score	Number of Test Takers	Notes
Mathematics Level 1	599	66,058	Algebra I, Geometry, and Statistics
Mathematics Level 2	690	145,140	Algebra I/II, Geometry/Trigonometry, Statistics
Biology (E)	616	31,965	E (Ecology Focus), M (Molecular Focus)
Biology (M)	647	40,231	
Chemistry	668	71,173	
Physics	667	56,751	

On content level exams such as the SAT II: U.S. History Exam, a score 500 (50th percentile) indicates that the student mastered *half* of the entire curriculum.

A score of 800 means that the student mastered the *entire* curriculum.

What's the "full" curriculum? By full, I mean covering *all* the standards and topics outlined in the exam prospectus.

Every Student Succeeds Act (ESSA) Accountability

ESSA no longer requires schools to make Adequate Yearly Progress (AYP) in Math and ELA.

But ESSA does require states to create their own measures of accountability in Math and ELA – and in some states science.

These measures require schools to increase scores over time.

[Building Level] Educational Leadership in STEM

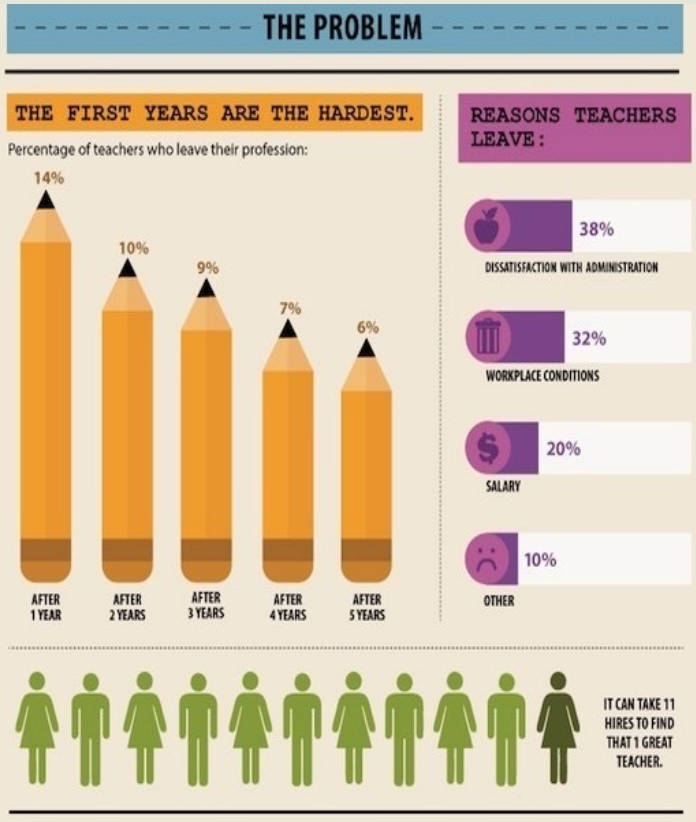
I don't know much STEM content so how can I be a helpful educational leader in this field?

Research shows that the majority of principals come from non-STEM backgrounds (ELA/Social Studies). **[15]**

Thus, they are likely to leave science teachers (especially at the secondary level) to their own devices. But, these teachers complain that the instructional feedback they receive is too broad or aimless.

So, understanding content matter is necessary to provide pointed feedback.

You can ask the teacher to provide you with the lesson in advance to see how well *you* can understand the material and concepts that are confusing to *you.* See how the teacher handles instruction especially for diverse learners.



Don't forget about new teachers!

New teachers need help especially since they are held to the same accountability and evaluation measures as veteran teachers.

Find ways early in their teaching career to combat isolation (e.g. one-on-one mentorship, schoolwide induction program, etc.)

Encourage them to pursue professional development teaching fellowships in STEM. **[16]**

[District Level] Educational Leadership in STEM

Academic Tracking: Good or Bad?

Academic tracking is the process by which students are separated based on academic ability. Tracking has been a subject of controversy.

Those against tracking argue that it is unfair to HUS, Special Education, and ELL students. **[17]** Those advocating tracking argue that it helps teachers with differentiation and can better meet student needs. **[18]**

Whether you are for or against tracking remember this: the lowest track, whatever it is, should cover the *full* curriculum needed for students to achieve proficiency on state standardized exams.

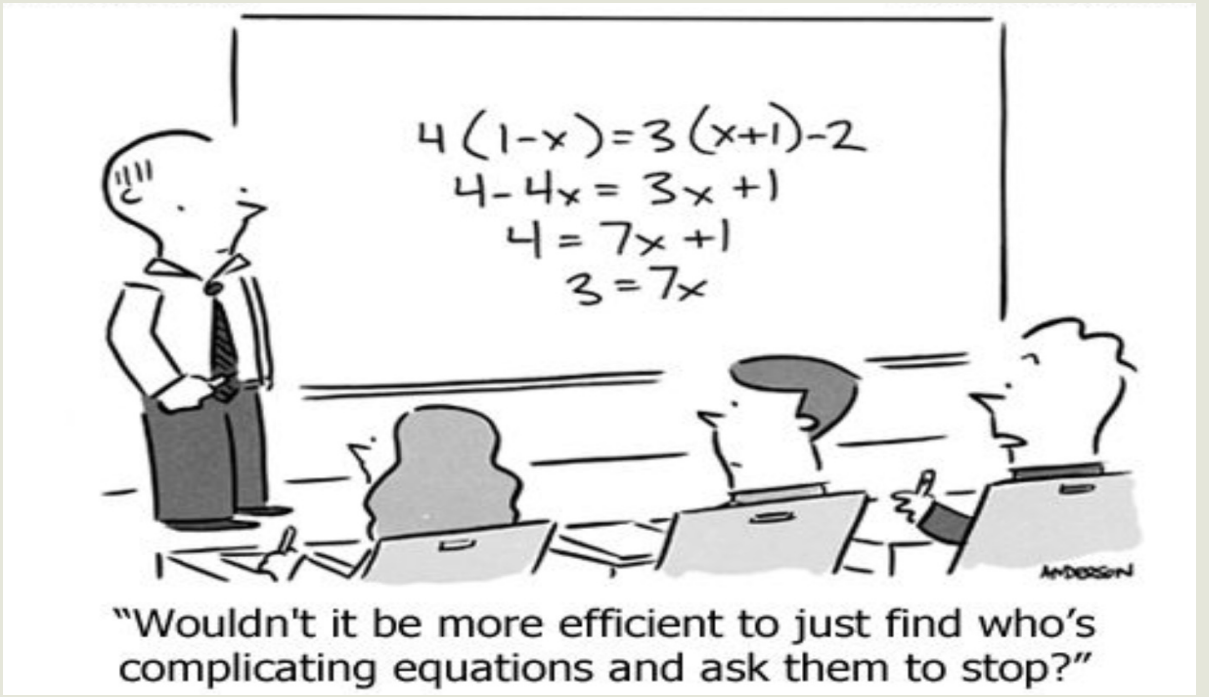
The Rising Tide of Grade Inflation

Research has shown that grade inflation has been on the rise in high schools and has almost reached parity with college inflation. **[19]**

Class grades should reflect first and foremost performance on classroom assessment. Too often grades include components that don't reflect mastery (e.g. attendance, participation, over emphasis on formative assessment).

Administrators can push departments or curriculum supervisors to develop a uniform grading scheme that does NOT vary from grade to grade.

In any case, be prepared to explain your reasoning and process to parents and students!



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