In its emergency plans in the event of an oil spill in the Gulf of Mexico, BP made clear it knows how to save "*seals, sea otters, and walruses*" in the *Gulf of Mexico* waters.

Gulf of Mexico = Artic Ocean

Chemicals Used to Mitigate Oil Spill

BP used the chemical Corexit 9500, pumped onto the sea bed at the point of the spill and also sprayed onto surface oil.

- Toxic to marine life
- Short Term: Chemical exposure can cause stomach pain, headaches, nausea, skin irritation and blurred vision.
- Long Term: chemical exposure can lead to far more serious side effects, including strokes, seizures and death.

(Virginia Department of Health)

Dear Teacher,

I am a survivor of a concentration camp. My eyes saw what no man should witness:

Gas chambers built by learned engineers.
Children poisoned by educated physicians.
Infants killed by trained nurses.
Women and babies shot and burned by high school and college graduates.

So I am suspicious of education. My request is: Help your students become human. Your efforts must never produce learned monsters, skilled psychopaths, educated Eichmanns.

Reading, writing, arithmetic are important only if they serve to make our children more human.







Seven Liberal Arts of Antiquity

Quadrivium (upper division) ⟹ Sciences

arithmetic, geometry, music, and astronomy

Trivium (lower division) ⟹ Humanities

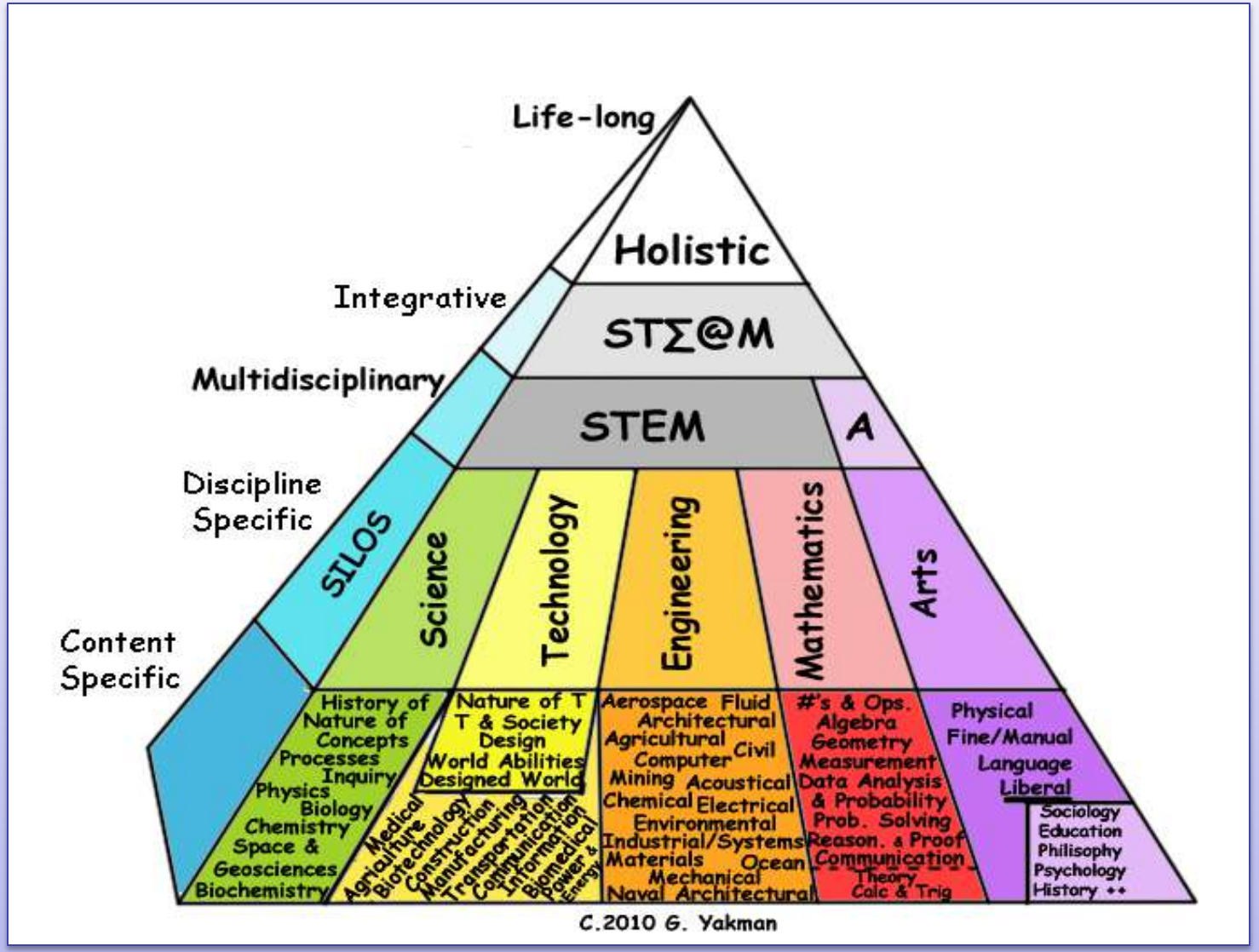
grammar (prose), rhetoric, and logic

Bifurcation of Science from STEM Initiatives

- Pitting Non-normative vs. Normative Views leads to…

- Abdication of any sense of *responsibility*

A Holistic Interpretation of Integrative "STEAM" Education



Seamless Integration of "STEAM" – Union of Quadrivium with Trivium

"It's in Apple's DNA that technology alone is not enough. We believe that it's technology married with the humanities that yields us the result that makes our heart sing … We think we have the right architecture not just in silicon, but in our organization, to build these kinds of products" (Steve Jobs, quoted in Isaacson, 2011, p.527).

Socioscientific Issues as a Sociocultural Stance

- SSI are by nature, controversial and ill-structured in their make up – but require evidence-based reasoning.
- Deliberate use of scientific topics that require students to engage in dialogue, discussion and argumentation.
- Tend to have implicit and explicit ethical components and require some degree of moral reasoning.
- Formation of virtue / character as a long-range pedagogical goal is often associated with SSI.

A Sociocultural Perspective

Practice of science *inseparable* from acts of responsibility

Prudence as the cultivation of scientific responsibility through the expression of social justice in the scientific community.

A Research-Informed Model of Scientific Literacy: Deficit to **Socioscientific Surplus**

(Statistically and Practical Significance…)

- Reflective Judgment / Epistemological Development
- Empathy / Caring
- Robust Argumentation / Discourse
- Nature of Science / Processes of Science
- Conceptual Understanding of Scientific Content / Transfer
- Moral Reasoning / Social Development
- Character / Responsibility
- Affective Considerations
- Ecological worldviews, socioscientific accountability, and social and moral compassion

Scientific Literacy as Responsible Decision-making

While literacy may not require a moral compass, scientific literacy, in the sense that I am prescribing, does.

Character Considerations

- By participating in carefully designed, socially responsible activities, students will hopefully develop or have reinforced such qualities as *reliability, trustworthiness, dependability, altruism, moral sensitivity, reflective judgment and compassion*.
- Such qualities are prerequisites for responsibility social actions that can possible reform and transform societal practices.

Transformative Science Education: Putting the "STEAM" in STEM

- In the process of cultivating scientifically literate citizens, our aim is to foster the formation of a *collective social conscience*.

- The goal is to *instill the desire to consistently hold one's actions up for internal scrutiny* (i.e., reflective reasoning) -- which is a fundamental feature of *conscience*.

- Character as a fundamental precondition for any notion of global sustainability.

Deficit to "Value Added" Science Education: Sociocultural Surplus

- STEM - inherently deficit model destined to produce another generation of uninvolved, unengaged and uninformed citizens.
- Reconceptualizing STEM model to be inclusive of sociocultural characteristics embedded in SSI research/pedagogy will more likely lead to a value-added model of surplus.
- "Value added" elements are realized by:
  - increased student engagement,
  - development of more sophisticated modes of reasoning,
  - more robust epistemological understanding of the nature of science
  - cultivation of character
  - responsible participatory citizenship

Evaluation of a US STEM Program – Avoiding the Faustian Bargain

Evaluation of a US University STEM Program

By Professor Dana Zeidler March 2015

Lack of a Coherent Program

"The *STEM* program as it is presently implemented, seems less of an integrated mathematics and science education program and more a collection of separate programs that share several common experiences."

Lack of Program Identity

"It became clear from interviews with both full-time and part-time students (with one exception) that their sense of professional identity was aligned along disciplinary-specific foci (e.g., Mathematics Education, Chemistry Education, Biology Education, etc.), but rarely with a "STEM" perspective or a Mathematics and Science Education integrated perspective."

Lack of Commitment to a Core Philosophy

"If the program wishes to market itself as a unique program that produces graduates with a core body of knowledge both within and among the disciplines, then a deliberate effort will need to be made both structurally and pedagogically to align those core philosophies with course work and faculty commitments."

Lack of an Integrated Program

"Faculty still tend to work in silos."

Identify *core* or *foundational* knowledge that should be acquired to prepare stewards of the disciplines of mathematics, science or whatever represents a collective sense of integrated knowledge.

This will likely require establishing some specific courses focusing on this core knowledge or revamping current offerings to insure that doctoral students have an opportunity to accumulate this knowledge. Such knowledge is not likely to result from assigned topical readings.

Retain Degree of Expertise in Specialization

Maintain the area of concentration in the discipline and strengthen if possible to enhance the foundational content knowledge of the graduates in their chosen discipline.

Encourage a Wide Perspective as to What Counts as Scholarship

Expand the view of what constitutes research as scholarship. The current view seems to be focused almost exclusively on empirical research—with philosophical, sociocultural and conceptual foundational pieces being excluded. When this happens at institutions, the results often produce "me too" studies and fewer works guided by well-crafted theoretical or conceptual frameworks that advance scholarship in the field in creative and novel ways.

What types of issues should be considered regarding opening a STEM Center?

1) How are you conceptualizing STEM? What counts as STEM for the planned center?

2) What is the mission and purpose of the center? This in turn should help define what such a center should do.

3) What is the financial model for the center? Who is paying for it and what do they expect and how long of a commitment is in place?

How can people such as teachers, students, university and other partners benefit from this center?

Many models for what this might be—just depends on *priorities*.

Some university centers are teaching and learning centers design to provide support for faculty and students improve their teaching.

Some are more oriented toward outreach to schools through things like teacher PD and/or student programming.

Some create new infrastructure for research and grants.

Transformative Science Education -- Putting the "STEAM" in STEM!

Thank You!