EAST ASIA:

EDUCATIONAL PRACTICES & STEM EDUCATION IN THE 21ST CENTURY

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Outline

- World Leaders
- Educational Approach
- Future Skills Needed
- STEM Education
- U.S. Educational Models of the Future
- Review
- Discussion Questions
- References

"At its core, it's about aligning education to the needs of the future economy. That's always what education has been about…preparing people for the world they are in."

–James Brown, Executive Director of the STEM Education Coalition

World Leaders

Vying for a piece of the economic pie

- 2017 World Economies
  1. *United States—24.32% ($18 trillion)*
  2. *China—14.84% ($11 trillion)*
  3. *Japan—5.91% ($4.4 trillion)*

* "The Asian bloc clearly has a larger share than anywhere else, representing just over a third (33.84%) of global GDP." (Gray, 2017)

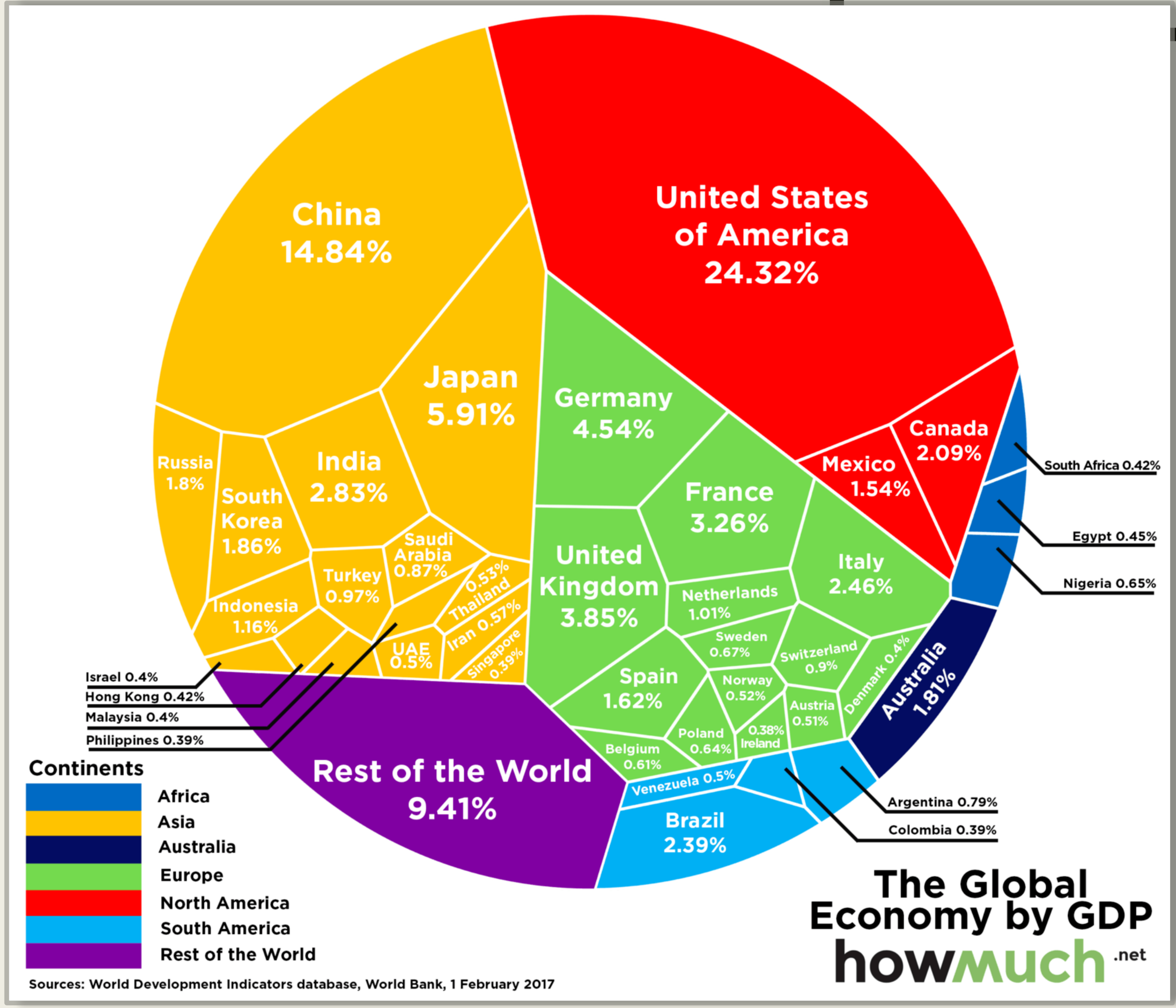


Image Source: https://www.weforum.org/agenda/2017/03/worlds-biggest-economies-in-2017/

World Leaders

Vying for a piece of the economic pie

- Notable Asian Economies
  1. *China—14.84%*
     (2018 Projection: Ranked 2nd)
  2. *Japan—5.91%*
     (2018 Projection: Ranked 3rd)
  3. *South Korea—1.86%*
     (2018 Projection: Ranked 11th)
  4. *Taiwan—Not Listed*
     (2018 Projection: Ranked 23rd)
  5. *Hong Kong—0.42%*
     (2018 Projection: Ranked 37th)
  6. *Singapore—0.39%*
     (2018 Projection: Ranked 40th)

  Percentages: (Gray, 2017)

  Rank: (List of countries, 2018)

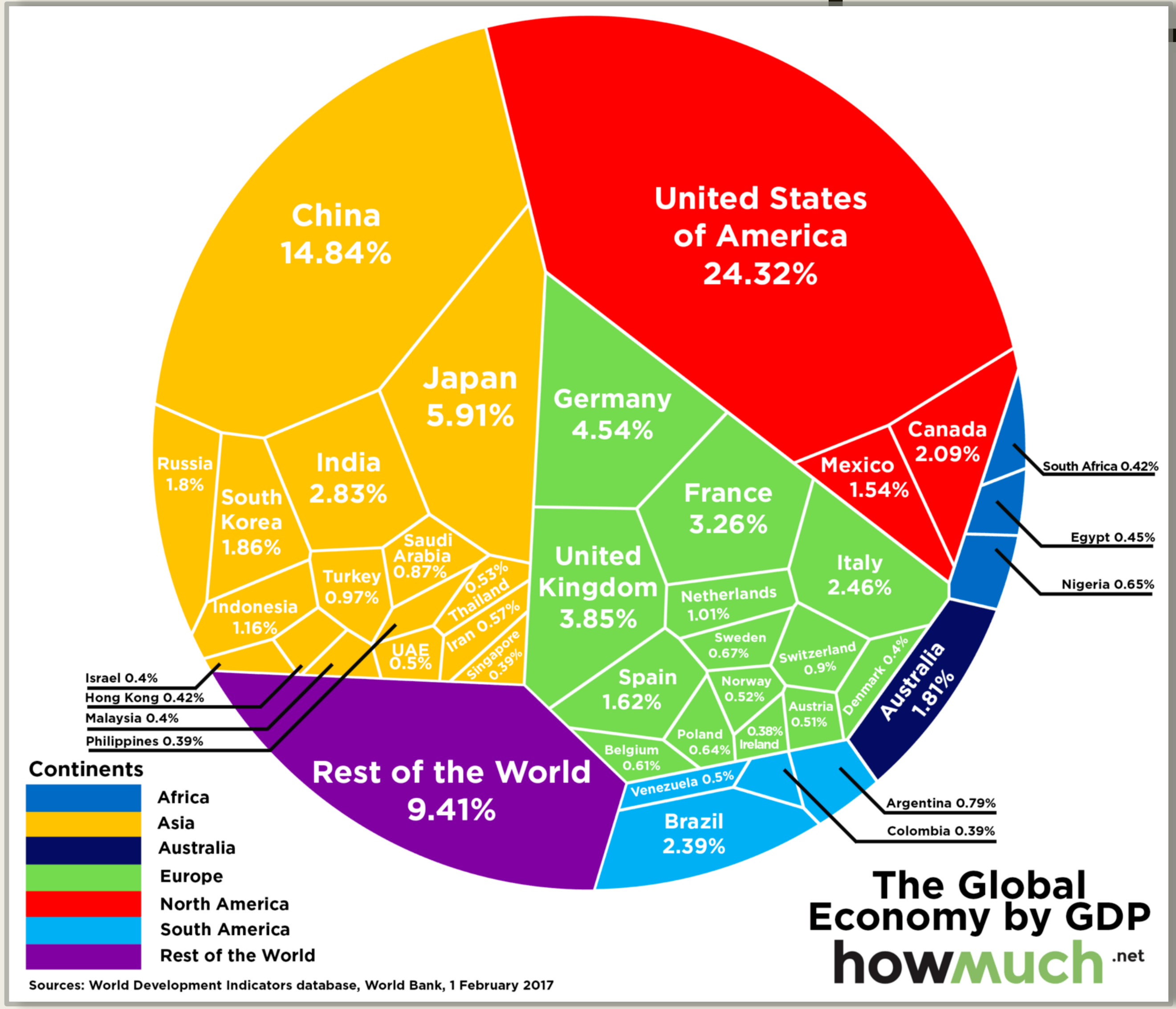


Image Source: https://www.weforum.org/agenda/2017/03/worlds-biggest-economies-in-2017/

World Leaders

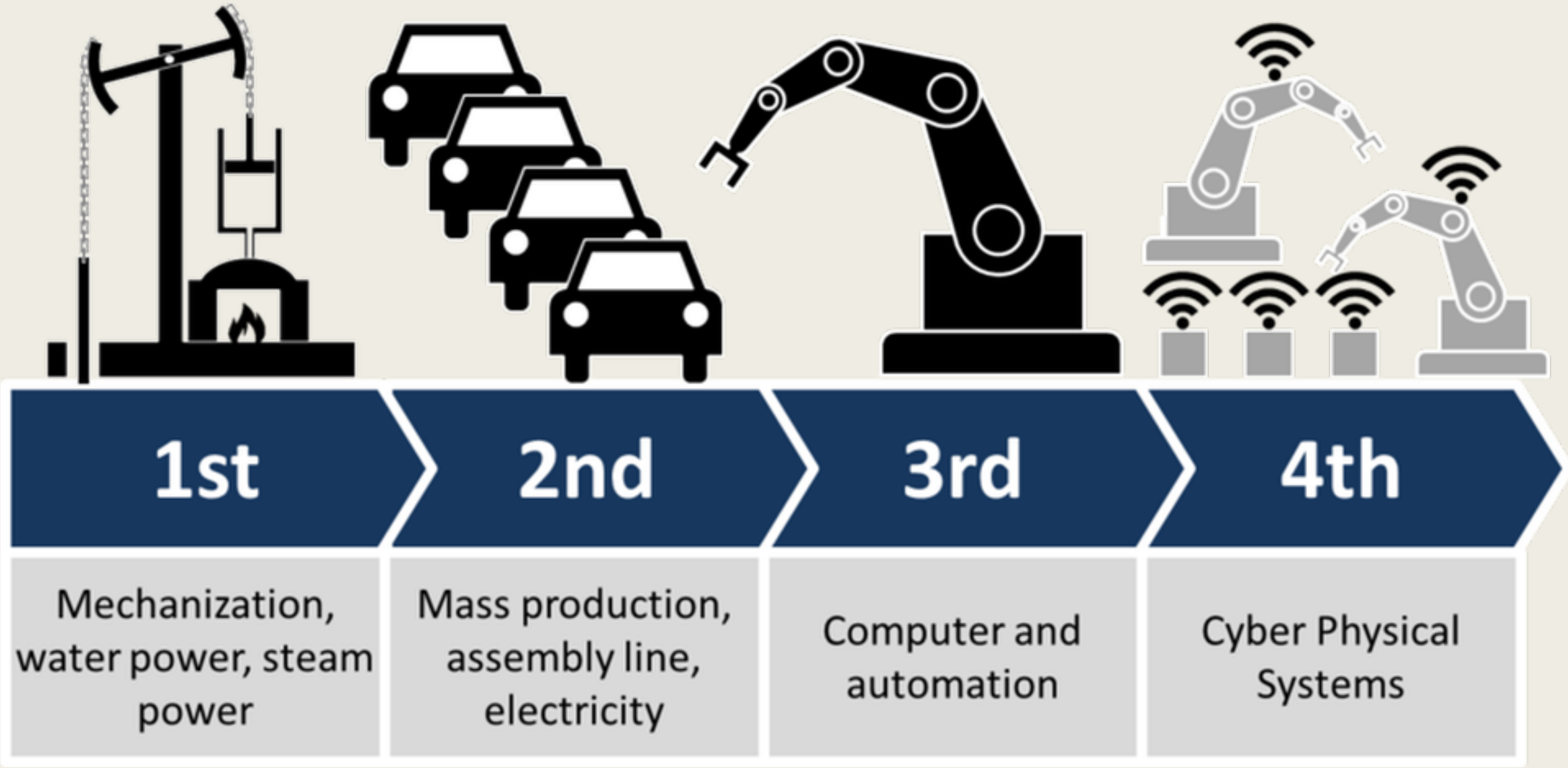
Vying for a piece of the economic pie

- 1st Industrial Revolution
  - *Mid-18th to Mid-19th Century*
- 2nd Industrial Revolution
  - *Late 19th to Early 20th Century*
- 3rd Industrial Revolution
  - *Mid-20th to Late 20th Century*
- 4th Industrial Revolution
  - *21st Century*

(Roy, 2018)

*Cyber Physical Systems (CPS) are integrations of computation, networking, and physical processes. (Cyber-physical systems, 2018)

The Four Industrial Revolutions



The 4 Industrial Revolutions (by Christoph Roser at AllAboutLean.com)

Image Source: https://www.forbes.com/sites/bernardmarr/2016/04/05/why-everyone-must-get-ready-for-4th-industrial-revolution/#305176173f90

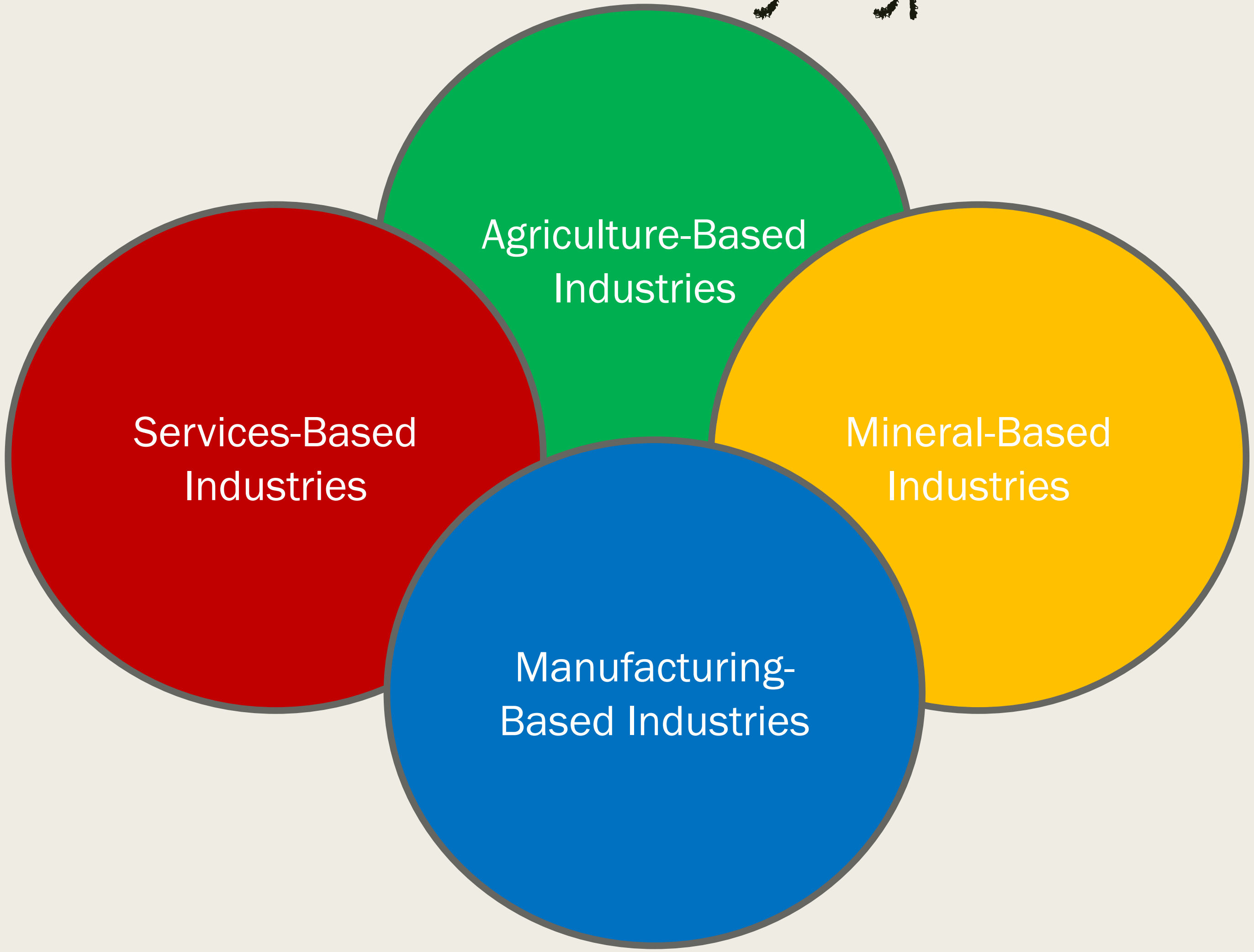
Economies & Technological Advancements

World Leaders

Vying for a piece of the economic pie

- Technological Advancements
    1. *China:* Alibaba, Tencent, NetEase, Baidu
    2. *Japan:* Sony, Toyota Motor, Toshiba, Hitachi (significant manufacturing/services), Panasonic, Nissan
    3. *South Korea:* Samsung Electronics, Hyundai Motor. KIA Motors, LG Electronics, SK Hynix
    4. *Taiwan:* Taiwan Semiconductor Manufacturing Company, Foxconn
    5. *Hong Kong:* Advanced Card Systems Holdings
    6. *Singapore:* Razer

Asian Industry: Types



Graphic Information Source: Asia Industry

"Economic triumph is tied to educational triumph. And in a world where business has no geographical or political boundaries, everyone everywhere is the competition."

–Dave Breitenstein, Audience/Metrics Analyst

Education

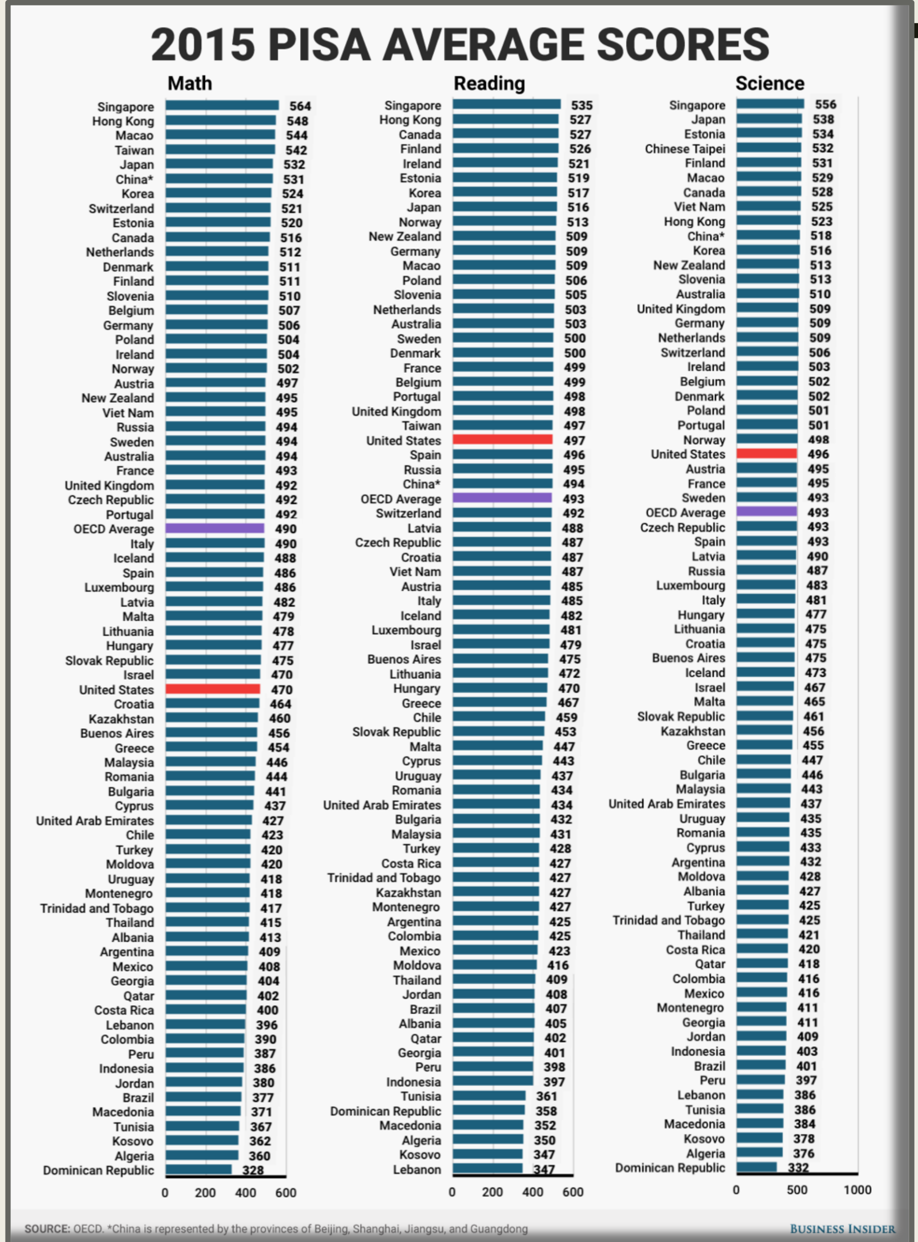
World Leaders

Vying for a piece of the economic pie

- Education Rankings (Specifically in Science and Math According to 2015 PISA Scores)
    1. *China (Represented by Beijing, Shanghai, Jiangsu, and Guangdong): Ranked 10th in Science and 6th in Math*
    2. *Japan: Ranked 2nd in Science and 5th in Math*
    3. *South Korea: Ranked 11th in Science and 7th in Math*
    4. *Taiwan: Not Listed in Science and Ranked 4th in Math*
    5. *Hong Kong: Ranked 9th in Science and 2nd in Math*
    6. *Singapore: Ranked 1st in both Science and Math*

- US Comparison: Ranked 25th in Science and 40th in Math (Jackson & Kiersz, 2017)

*PISA: Program for International Student Assessment



World Leaders

Vying for a piece of the economic pie

- Education Rankings (Specifically in Science and Math according to the Trends in International Mathematics and Science Study 2015)
  - *Among the Highest Achieving Countries in 4th and 8th Grade Mathematics*
    - Singapore, Korea, Hong Kong SAR, Chinese Taipei (Taiwan), and Japan
  - *Among the Highest Achieving Countries in 4th Grade Science*
    - Singapore, Korea, and Japan
  - *Among the Highest Achieving Countries in 8th Grade Science*
    - Singapore, Japan, Chinese Taipei (Taiwan), and Korea (TIMSS 2015, 2018)

East Asia

Educational Approach

Vying for a piece of the economic pie

- Cultural View
  - “The difference between Asian and American education systems is cultural.” (Breitenstein, 2013)
  - Education seen as the only pathway to success throughout much of Asia (Breitenstein, 2013)
  - Fueling Asia’s Academic Ascension:
    - Parental demands
    - Fear of failure
    - Competition
    - Pride (Breintenstein, 2013)
  - “In dozens of interviews at nine Asian schools and universities, college officials, faculty, principals and parents repeated the same terms when describing the typical Asian student: committed, diligent, competitive, passionate, focused and ambitious.” (Breitenstein, 2013)
  - ”Parents, students, teachers, and policy makers share a highly positive but rigorously instrumentalist view of the value of education at the individual level.” (Hogan, 2014)
  - “Two traits pervade the culture and are taught by both parents and teachers: effort and persistence.” (ERN, 2004)
  - Confucian priority of advancement through exams (Lowry, 2018)

East Asia

Educational Approach

Vying for a piece of the economic pie

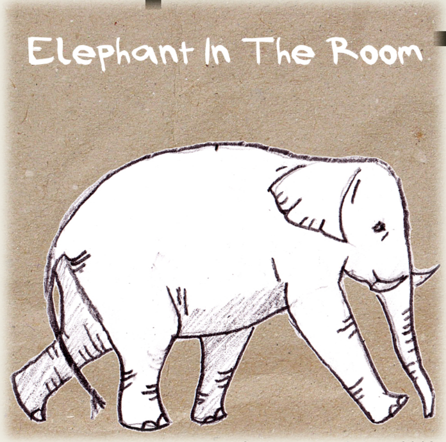


Image Source: [Venue Church](), 2018

- Cram Schools
  - *Japan Juku (学習塾 or 塾)*
  - *Korea Hagwon (학원學院)*
  - *Taiwan Buxiban (補習班 or 补习班)*
  - *Hong Kong Tutorial school (補習班 or 補習社) (Cram school, 2017)*
  - Specialized schools that train their students to meet particular goals, most commonly to pass the entrance examinations of high schools or universities (Cram school, 2017)
  - High attendance rate despite financial burden ranging from $90-$450 a month (Takiguchi, 2015)
  - History of civil service exams in China leading to tutors (Ripley, 2011)
  - Frequency ranges from 2-5 times per week for multiple hours (Takiguchi, 2015)

East Asia

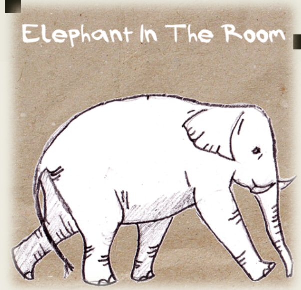


Image Source: Venue Church, 2018

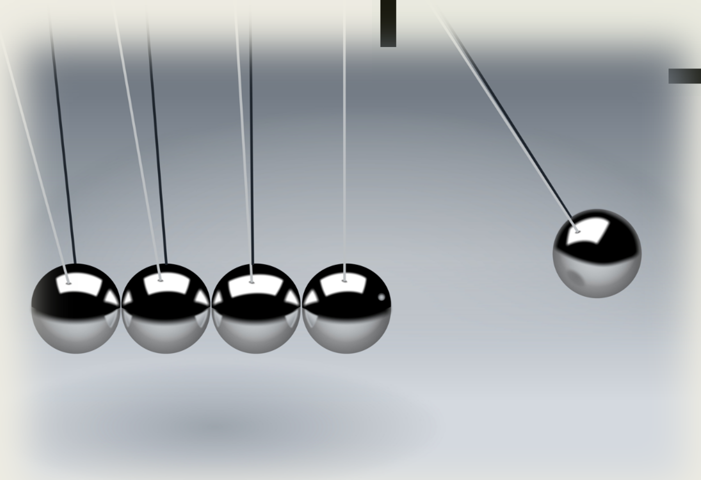
Educational Approach

Vying for a piece of the economic pie

- Teacher Education Levels
  - *High level of parallel majors in Singapore (Ex: An elementary science teacher majoring in both education and chemistry, biology, or physics) (Lowry, 2018)*
  - *"Only the top 25% of college students enter the education field" in Singapore. (Lowry, 2018)*
  - *Primary grades: Singapore—"highly qualified mathematics teachers whose pedagogy centers on teaching to mastery" vs U.S.—"too many U.S. teachers lack sound mathematics preparation" (Ginsburg, Leinwand, Anstrom, & Pollock, 2005)*
  - *Low level (almost none) of out-of-field teaching in Japan at the secondary level for Math and Science compared to the U.S. (U.S. out-of-field: Math—32%, Science—29%) (Ingersoll, 2007)*
  - *Low level of out-of-field teaching in Korea at the secondary level for Math compared to the U.S. (Ingersoll, 2007)*
  - *Study on elementary teachers in China and the U.S.: "…Chinese teachers had a more profound understanding of the mathematics they were teaching. This deeper understanding both of mathematics content and its application allowed Chinese teachers to promote mathematical learning and inquiry more effectively than their counterparts in the United States." (National Research Council, 2000)*

Educational Approach

Vying for a piece of the economic pie



- Pedagogical Practices
  - *Singapore* *(PISA: Ranked 1st in both Math & Science)*
    - Mathematics
      - *Classroom instruction highly-scripted and uniform across all levels and subjects*
      - *Primary focus on coverage of curriculum, transmission of factual and procedural knowledge, and preparing students for end-of-semester and national high stakes examinations*
      - *Heavy reliance on textbooks, worksheets, worked examples, and lots of drill and practice (Hogan, 2014)*
    - Science
      - Reluctance in using inquiry methods because assessment of inquiry skills is not included on national tests
      - *Desire among policy makers for teachers to develop inquiry teaching methods but a hesitancy to execute the plan (Lowry, 2018)*

East Asia

Educational Approach

Vying for a piece of the economic pie

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- Pedagogical Practices Continued
  - *Japan (PISA: Ranked 5th in Math & 2nd in Science)*
    - Mathematics
      - *Reforms during the 1970s and 1980s*
        - Shift from a traditional classroom that focuses on teachers' instruction, to a student-centered classroom that focuses on students' engagement in mathematical activities (Gardner, 2016)
        - Irony: Japanese math is actually based on a method 1st advocated in the U.S. by the National Council of Teachers of Mathematics in the 1980s but never fully adopted by classroom teachers. (Gardner, 2016)
        - Hatsumon (question addressing a concept), structured problem solving
          - *"I, We, You" → "You, Y'all, We" (Green, in O'Donoghue, 2014)*
        - Jugyokenkyu (lesson study)—Teachers are routinely observed in order to help hone their craft (Green, in O'Donoghue, 2014)
        - Japanese (more) vs U.S. (less) allocation of time spent explaining new concepts (Mathematics teaching in japan, 2004)
    - Science
      - *Science teaching in elementary schools depends mostly on observations and experiments*
      - *Inquiry based teaching fades in secondary education and mostly disappears in upper secondary education (Ogura, 2013)*

Educational Approach

Vying for a piece of the economic pie

Photo by yu wei on Unsplash

- **Pedagogical Practices Continued**
  - *China* *(PISA: Ranked 6th in Math & 10th in Science)*
    - Mathematics
      - *Mastery Model/Approach: based on the idea that all students can succeed in learning mathematics when given proper instruction*
        - **Western Teachers** (describe a concept and then assign problems for students to solve individually) **vs East Asian Teachers** (pose questions to students who are then expected to precisely explain both solutions and underlying principles in front of their classmates)
        - Fewer concepts allows for greater depth (Qin, 2017)
    - Science
      - *Curriculum Standards: emphasize inquiry as the core of science learning*
      - *(2001) Learning By Doing Program: Hands-on Inquiry Based Learning and Teaching (Wu, 2015)*

Educational Approach

Vying for a piece of the economic pie

East Asia

Photo by Ousa Chea on Unsplash

- Pedagogical Practices Continued
  - *South Korea* *(PISA: Ranked 7th in Math & 11th in Science)*
    - Mathematics
      - *Rote Learning: memorization based on repetition (South korean teens, 2017)*
    - Science
      - *Teacher-centered and lecture-based teaching methods*
      - *"Science is a subject that students learn as integrated with mathematics."*
      - *Incorporate quantitative reasoning*
      - *Specialized, highly gifted science schools present in each province (Wichmanowski, 2015)*

Future Skills Needed (According to the World Economic Forum)

21st Century Skills

Vying for a piece of the economic pie

Figure 1

WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

Top 10 skills

in 2020

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgment and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

in 2015

1. Complex Problem Solving
2. Coordinating with Others
3. People Management
4. Critical Thinking
5. Negotiation
6. Quality Control
7. Service Orientation
8. Judgment and Decision Making
9. Active Listening
10. Creativity

Source: Future of Jobs Report, World Economic Forum

Figure 2

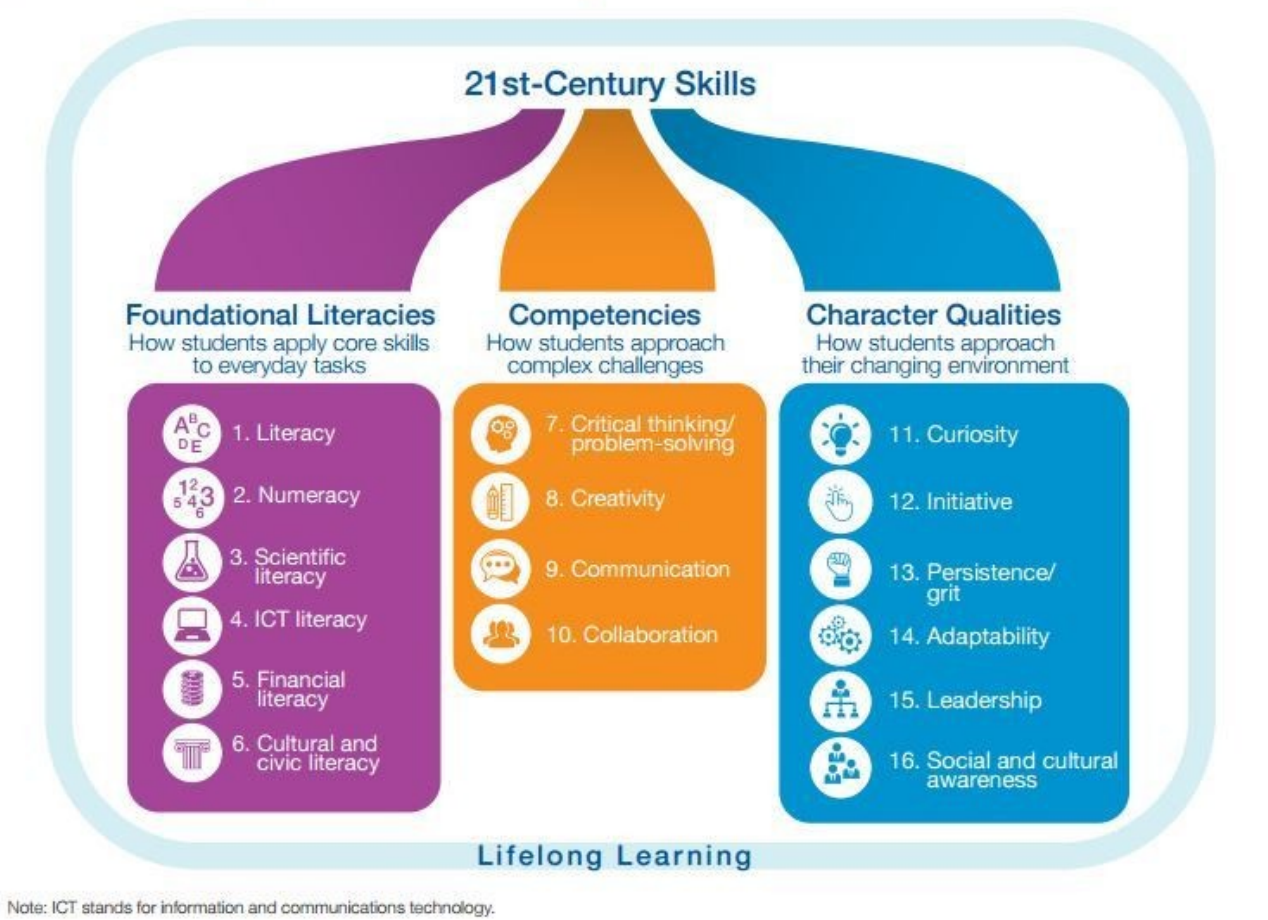

Image Source: World Economic Forum, New Vision for Education (2015)

21st Century Skills

Future Skills Needed

Vying for a piece of the economic pie

- Skills
  - *#1 Complex Problem Solving*
  - *PISA results indicate that American students do not perform well on problem-solving tasks in comparison to other participating OECD countries the U.S. competes with economically. (Bybee, 2013, p.29)*
  - *"Within STEM, teaching science as inquiry and engineering as design seems a straightforward way to address the issue of enhancing problem-solving abilities. Although there seems to be a clear need for higher levels of achievement in basic science concepts, developing the abilities of scientific inquiry and engineering design would contribute to the preparation of a 21st century workforce." (Bybee, 2013, pp. 29-30)*

21st Century Skills

Future Skills Needed

Vying for a piece of the economic pie

- **Our globe needs citizens who understand and are ready to address STEM-related challenges such as the following:**
  - *Economic stability and the development of a 21st century workforce*
  - *Economic efficiency and adequate responses for a carbon-constrained world*
  - *Environmental quality and the need for evidence-based responses to global climate change*
  - *Resource use and the need to address continuing conflicts over limited natural resources*
  - *Mitigation of natural hazards by preparing for severe weather, earthquakes and fires*
  - *Health maintenance and the need to reduce the spread of preventable diseases*
  - *Public understanding of the role of scientific advances and technological innovations in health and human welfare (Bybee, 2013, pp.34-35)*
- "The global challenges citizens face are clearly significant and will require more than education solutions, but STEM education must be part of any response" (Bybee, 2013, p.35)

Educational Models/ Perspectives

STEM Education

Vying for a piece of the economic pie

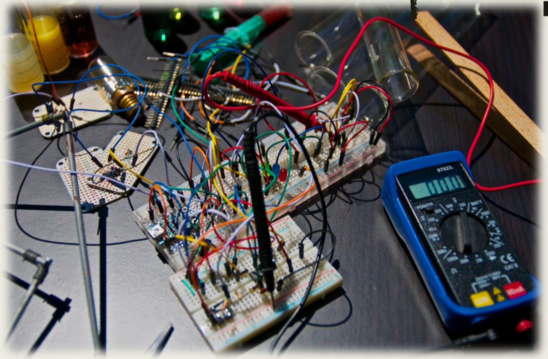

Photo by Nicolas Thomas on Unsplash

- What is STEM Education?
  - *Ambiguous definition among stakeholders and educational entities*
  - *“A true STEM education should increase students' understanding of how things work and improve their use of technologies. STEM education should also introduce more engineering during precollege education. Engineering is directly involved in problem solving and innovation, two themes with high priorities on every nation's agenda. Given its economic importance to society, students should learn about engineering and develop some of the skills and abilities associated with the design process.“ (Bybee, 2010)*

Educational Models/ Perspectives

STEM Education

Vying for a piece of the economic pie

Figure 1 Single-Discipline Reference

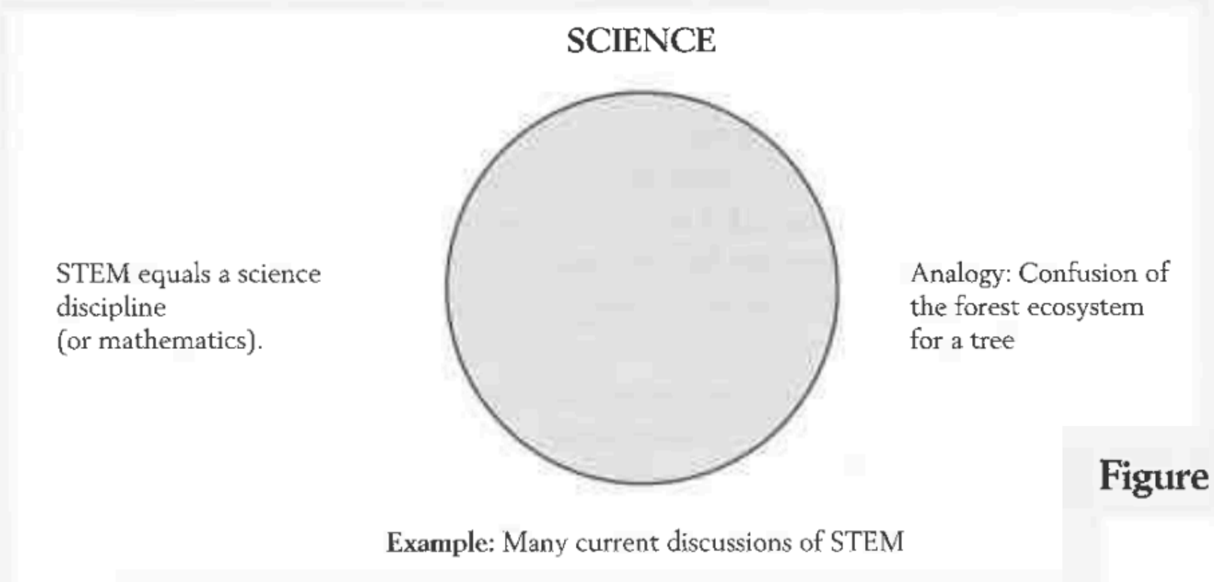

Image Source: Bybee, 2013, p. 74

- **Figure 1 Single-Discipline Reference:**
  - *A single course*
  - *Generally a Science or Math course*
  - *Confusing due to the multiple disciplinary orientations contrasted with the single discipline reference (Bybee, 2013, p.74)*

Figure 2 STEM as a Reference for Science and Math

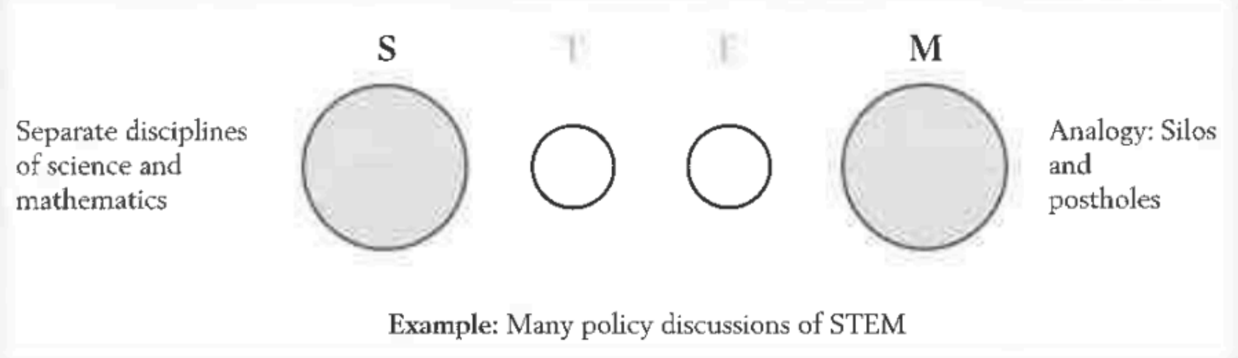

Image Source: Bybee, 2013, p. 75

- **Figure 2 STEM as a Reference for Science and Math:**
  - *Science and Math are separate disciplines (silos)*
  - *Technology and Engineering are simply empty space links (postholes) (Bybee, 2013, p.75)*

Educational Models/ Perspectives

STEM Education

Vying for a piece of the economic pie

Figure 3 Separate Science Disciplines That Incorporate Other Disciplines

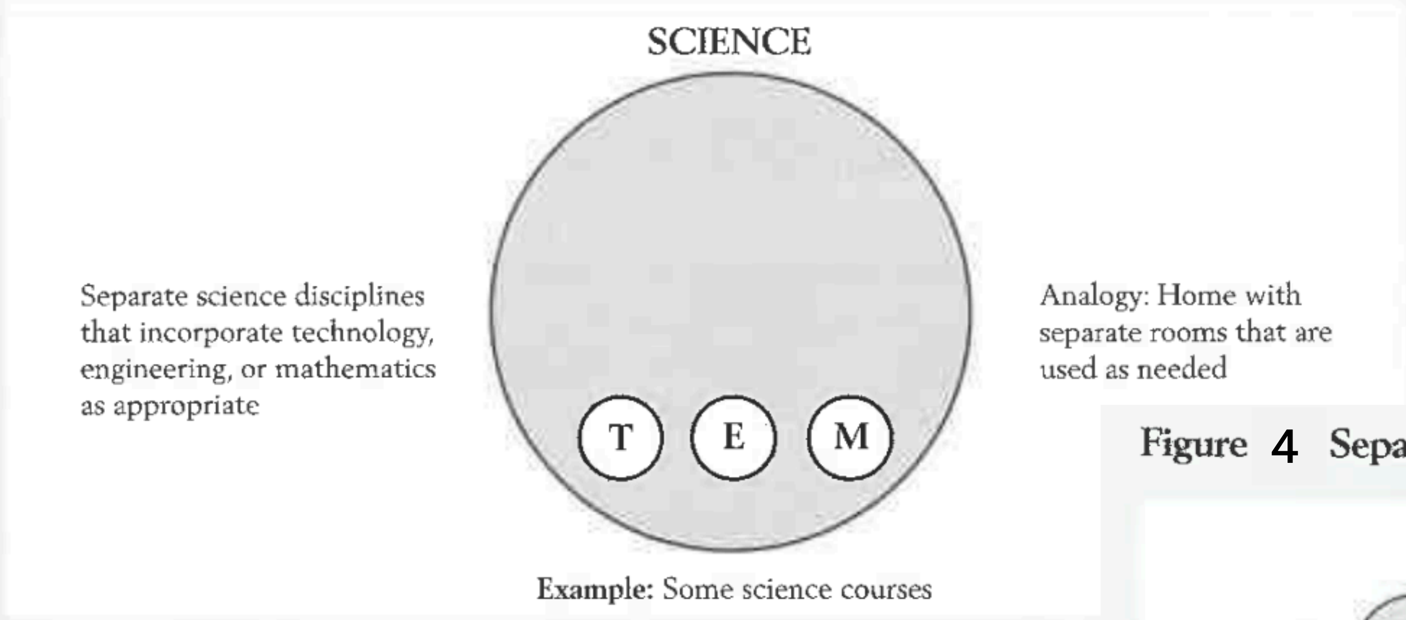

Image Source: Bybee, 2013, p. 75

- Figure 3 Separate Science Disciplines That Incorporate Other Disciplines:
  - *Representation of the first step toward an integration*
  - *Science or Math is still kept as the dominant discipline (Bybee, 2013, p.75)*

Figure 4 Separate Disciplines

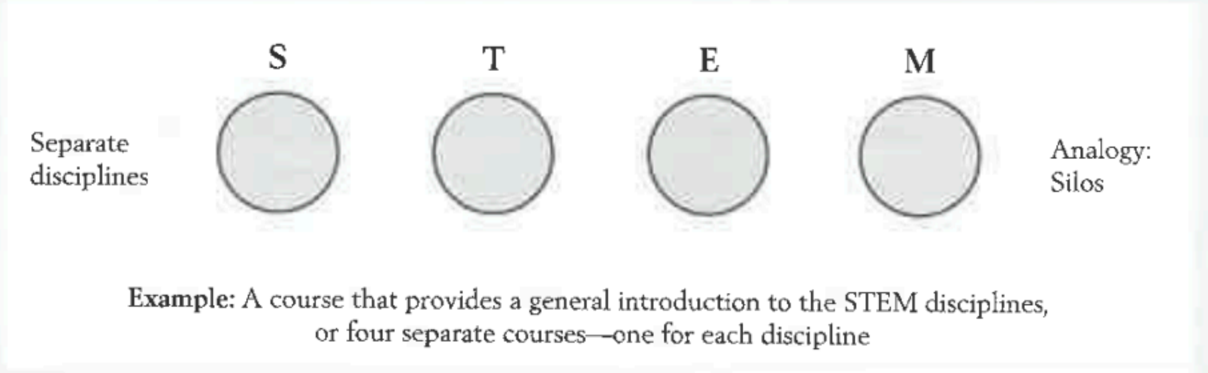

Image Source: Bybee, 2013, p. 76

- Figure 4 Separate Disciplines:
  - *Each discipline (silo) has a place in the curriculum but equality may not be the case despite equal representation in the diagram (Bybee, 2013, p.76)*

STEM Education

Vying for a piece of the economic pie

Figure 5 Science and Math Connected by Technology or Engineering Program

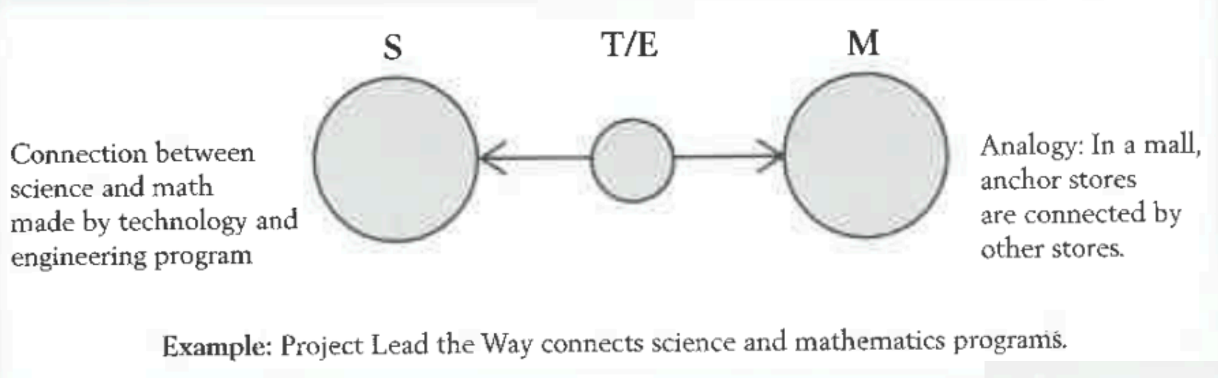

Image Source: Bybee, 2013, p. 77

- Figure 5 Science and Math Connected by Technology or Engineering Program:
  - *Science and Math are stand-alone disciplines with connections to another program that emphasizes technology and/or engineering*
  - *Ex: Career and Technical Education (CTE) programs*
  - *Student experience in work-based learning (Bybee, 2013, pp.76-77)*

Figure 6 Coordination Across Disciplines

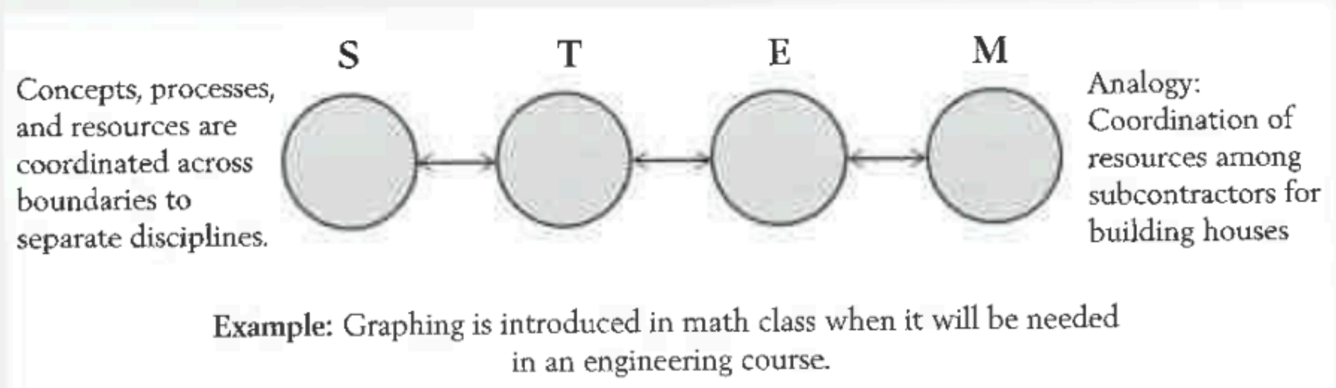

Image Source: Bybee, 2013, p. 77

- Figure 6 Coordination Across Disciplines:
  - *Teachers work together to introduce concepts that are relevant and may be applied in other content areas*
  - *Reality = two of the four disciplines likely will coordinate concepts and processes (Bybee, 2013, p.77)*

STEM Education

Vying for a piece of the economic pie

Figure 7 Combining Two or Three Disciplines

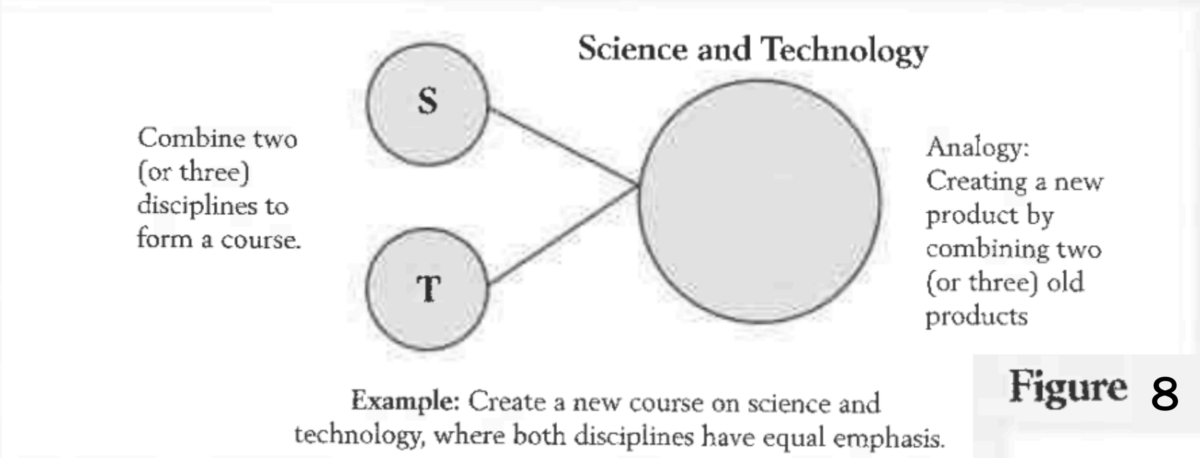

Image Source: Bybee, 2013, p. 78

- Figure 7 Combining Two or Three Disciplines:
  - *A form of integration that could include multiple combinations (Bybee, 2013, p.78)*

Figure 8 Integrated Disciplines

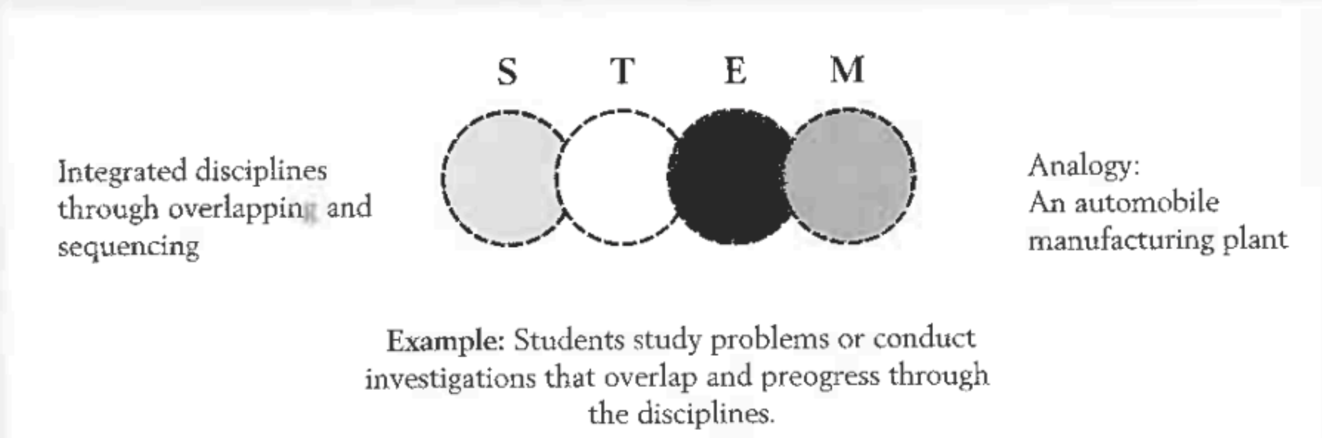

Image Source: Bybee, 2013, p. 79

- Figure 8 Integrated Disciplines:
  - *STEM becomes a central emphasis of the education experience (Bybee, 2013, p.78)*

STEM Education

Vying for a piece of the economic pie

Educational Models/ Perspectives

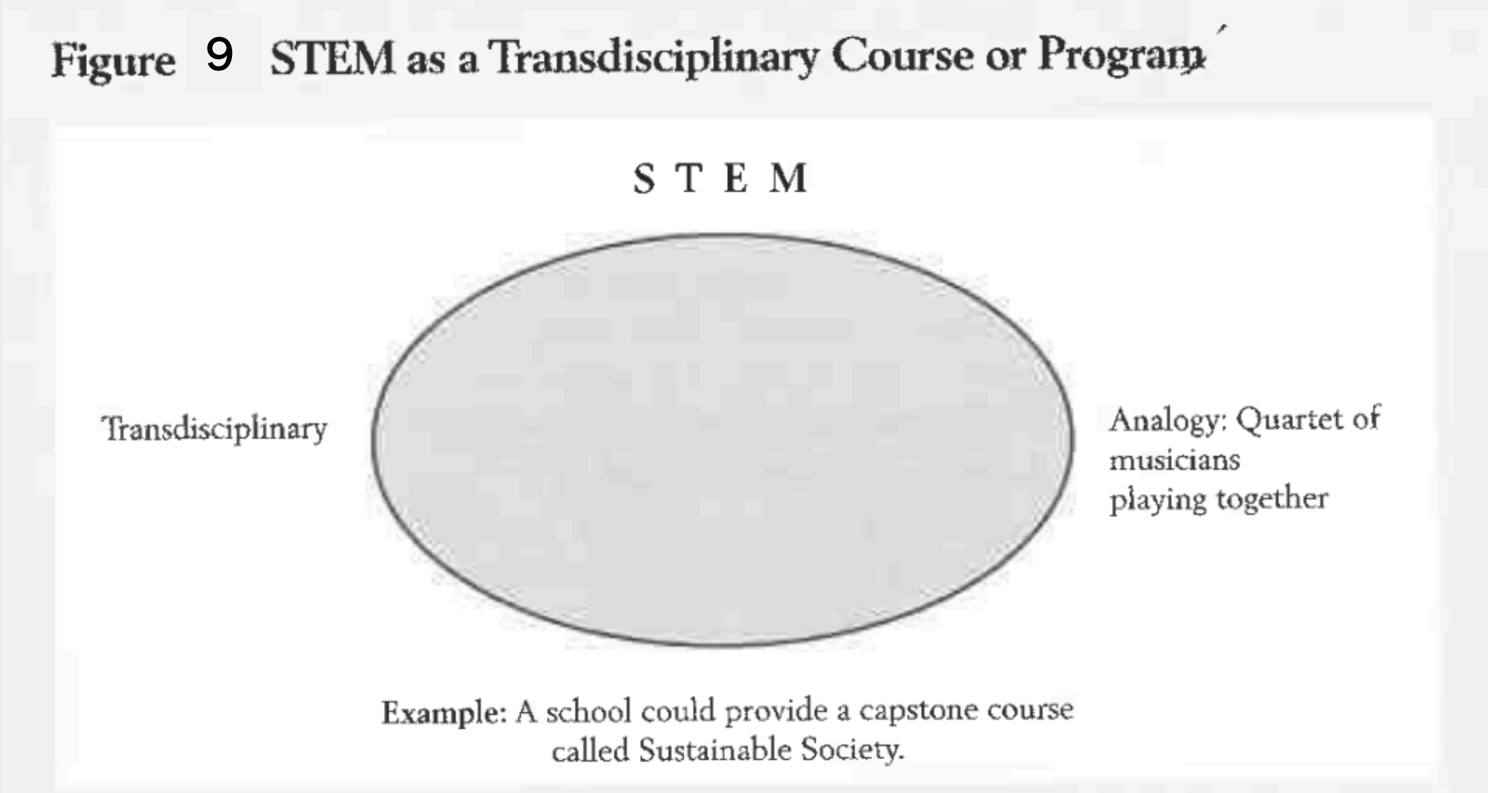

Image Source: Bybee, 2013, p. 79

- Figure 9 STEM as a Transdisciplinary Course or Program:
  - *The entire group of STEM disciplines could be used to understand major issues or contemporary challenges (Bybee, 2013, p.78)*

U.S. Educational Models of the Future

Educational Models/ Perspectives

Vying for a piece of the economic pie

"The Buddha is believed to have asserted, *'Do not dwell in the past, do not dream of the future, concentrate the mind on the present moment.' Both countries are longing to become the other: Singapore seeks to inject more creativity and innovation into its education system while the US seeks to create a more rigorous standards based system that guarantees rigor. I would remind readers that it is not an either/or option and that a third way combines both. In the US, STEM educators are beginning to explore the Next Generation Science Standards (NGSS), a document that is charting a new course in teaching and learning. This reform document can be the 'third way' that allows elements of both systems to thrive under one umbrella."*

Michael Lowry– Former High School Director for the National Science Teachers Association (NSTA), Presidential Awardee for Excellence in Science Teaching

Review & Discussion

Review

- **World Leaders: Economies and Technological Advancements**
  - *East Asian countries are competing for a larger piece of the economic pie and are gaining ground*
  - *The 4^{th} Industrial Revolution is changing the landscape of skill sets needed by the future workforce*
- **World Leaders: Education**
  - *Several notable East Asian countries (China, Japan, South Korea, Taiwan, Hong Kong, and Singapore) scored high on the 2015 PISA (assessed every 3 years) and the 2015 TIMSS (assessed every 4 years) in Math and Science*
  - *The US ranked 25^{th} in Science and 40^{th} in Math on the 2015 PISA*
- **Educational Approach: East Asia**
  - *Cultural views place a high value on education*
  - *Cram schools are heavily utilized*
  - *Out-of-field teaching is low*
  - *Pedagogical Practices: Variances in highly-scripted instruction, teacher and student-centered classrooms, inquiry-based methods, rote learning, concept coverage amounts, structured problem-solving, and reflection strategies*
- **Future Skills Needed: 21^{st} Century Skills**
  - *1. Complex Problem Solving, 2. Critical Thinking, 3. Creativity, 4. People Management, 5. Coordinating with Others, 6. Emotional Intelligence, 7. Judgment and Decision Making, 8. Service Orientation, 9. Negotiation, 10. Cognitive Flexibility*
- **STEM Education**
  - *Ambiguous definition*
  - *Differing models/perspectives*
- **US Educational Models of the Future**
  - *Proposal of a “third way”*

Discussion Questions

- World Leaders: Economies and Technological Advancements
  - *Identify your local and state economic leaders. Is your school and/or school capitalizing on partnerships with these identified leaders in order to establish a pathway for students to acquire the needed 21st century skills these economic leaders seek prior to students entering the workforce? If so, what do these partnerships look like, and how can they be strengthened? If not, what immediate steps can be taken to begin establishing sound partnerships?*
  - *In what ways is the 4th Industrial Revolution shift changing the landscape of production and services provided by the economic leaders you identified? How do these changes affect the direction your local and state education system takes to prepare students for the future workforce needed by these economic leaders?*

**Difficulty in answering these questions may indicate a need to seek out contacts within your school district, at the state level, and within local and state economic leader circles who could assist in answering these questions and provide directional guidance.*

Discussion Questions

- World Leaders: Education
  - *The US ranked 25th in Science and 40th in Math on the 2015 PISA, far below the aforementioned East Asian countries. Identify several reasons why you feel this has occurred and discuss the possible implications for the US in terms of scores and economics if it continues with its current approach to educating students in Science and Math.*
  - *Like reading, math is a gateway subject and a critical problem in the U.S. is significantly improving elementary teacher competence in and affinity for mathematics. How can STEM leaders at the school and district levels identify and learn from high achieving, data-driven, elementary school mathematics programs in public school districts, schools, (including charter, magnet, private, and home school networks)? Since most public schools hire a majority of teachers who live or were educated within a 100 mile radius of the locale of a given school district, how can STEM leaders identify the colleges and universities graduating aspiring elementary teachers with high Praxis math scores and systematically recruit these high achievers for positions?*

Discussion Questions

- Educational Approach: East Asia
  - *Cultural views place a high value on education in East Asian countries which has, arguably, aided in high scores on the PISA as well as the TIMSS. What can schools, districts, states, and entities at the national level do or promote to increase the value of education, culturally, here in the US?*
  - *What alternates to crams schools can US educators promote, and do these have the potential to provide similar or enhanced learning experiences to students in comparison to cram schools? (Ex: extended learning and after-school programs offered)*
  - *Consider the education levels and degrees of the teachers at your school and within your district. Are significant numbers teaching out-of-field? Do educators teaching Science and Math in your school and district have parallel majors in a Science or Math?*

Discussion Questions

- Future Skills Needed: 21st Century Skills
  - *What specific skill sets do identified economic leaders in your area currently require, and what skill sets do they project will be needed to fill their future positions based on the changes brought forth by the 4th Industrial Revolution shift?*
  - *How is your school, district, and state addressing the need to provide educational opportunities where students are able to develop 21st century skills identified in Future Skills Needed: Figure 1 and identified by your local and state economic leaders?*
  - *"Are 21st century skills different from traditional skills and abilities developed by education in the STEM disciplines?" (Bybee, 2013, p. 40)*

**Difficulty in answering these questions may indicate a need to seek out contacts within your school district, at the state level, and within local and state economic leader circles who could assist in answering these questions and provide directional guidance.*

Discussion Questions

- STEM Education: Educational Models/Perspectives
  - *How is STEM education defined and approached at your school, in your school district, and at the state level?*
  - *Is STEM Education the single answer to equipping students with 21st century skill sets, or should there be an amalgamation of practices employed to reach this goal? If the latter, what practices and resources would the amalgamation include?*
  - *Project-Based and Place-Based Learning are approaches often associated with STEM education. Does your school, school district, and state promote the employment of Project-Based and Place-Based Learning? If so, what 21st century skills are your students developing through these approaches?*
  - *Innovation has been proposed as a national issue. Assuming it is, what could STEM education do to encourage innovation? (Bybee, 2013, p. 71)*

Discussion Questions

- US Educational Models of the Future: Educational Models/Perspectives
  - *Michael Lowry points to the Next Generation Science Standards (NGSS) and proposes the possibility of them serving as the "third way". After familiarizing yourself with NGSS, how might these standards and approach to these standards potentially prepare students to not only perform well on rigorous high-stakes tests as their counterparts do in East Asian countries previously identified but to develop the skill sets required of the future workforce that lead to more creativity and innovation?*
  - *Is there a possible differing "third way" specific to your school, district, and/or state? If so, what state-level and/or national-level resources are available to you, your school, and your district for aid in devising and implementing a "third way" catered to your student needs and with your power of place in mind? (Ex: [Tennessee STEM Innovation Network]* and the TN Department of Education's *[STEM Strategic Plan]* (state-level), *[STEMx] (national-level))*
  - *What steps has your school, district, and/or state taken to simultaneously address student performance on high-stakes tests and the employment of educational practices that allow students to develop* 21st *century skill sets?*

[Next Generation Science Standards]

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