Overall Summary

- Two Macro Technological “Cyber” Revolutions underway:
  - Intelligent Machines/AI in 3D space (robotics)
  - Intelligent Machines/AI at Rest, “The CLOUD” & IoT…also known as Cyberspace.

State Higher Education Systems have a key role to play… for the common good…educational equity and student security.

- (Note: Norbert Weiner used the term “Cybernetics” for early automated processes. Today we more commonly think of “Cyber” as the Cloud and the virtual world. I will generally use the latter terminology for our purposes here).
• 1. Ensure access to **Cyberspace/Digital Education ACROSS YOUR STATES**…
  - Imperative to counter a concentrating momentum that appears to be emerging (Silicon Valley effect…) as a result of market forces spilling over into the education system.
  - Equity is eroding.
  - Rural and post-Industrial areas are lagging most.
  - Achieving the needed speed and scale of effective action in the lagging areas is problematic.

State Higher Education Systems have a key role to play…*for the common good…educational equity and security.*
Summary at the System Level: 1. Education Equity 2. System Campus Security

2. Protect your campuses and students from Cyber attack…
   - Intellectual Property.
   - Privacy and physical well being of your students and faculty and staff at all campuses, both well off and less well funded.
   - The technical staff cannot do it alone; they need executive/board support that understands the tradeoffs needed to achieve the appropriate levels of security and accessibility.

State Higher Education Systems have a key role to play… for the common good… educational equity and security.
Digital Technological Change as THE Driver of our Time

- Kelly, “What Technology Wants”
- McAfee/Brynjolfsson, “Race Against the Machine”
- Beniger, “Control Revolution”; Gleick, “The Information”
- Singer, “Cyber Security and Cyberwar”
- Dark Web insights read Olson, “We are Anonymous”
- And… Kasson, “Civilizing the Machine” (to inspire the lawyers/humanists/religious thinkers in our group)
What are your theories of Technological Change?

Challenge to Education Leaders: understanding nexus of the human-machine–information-our campuses… then develop ideas to lead our organizations…so…what theories of technological change might help us?
What theories of Technology help place our time and our challenges in perspective?

1. “Momentum” theory of technological change

2. ‘Sense-Think-Act’ continuous improvement is a human impulse… and it is integrating with digital technology

3. Dual Macro Revolutions: a. Autonomous/Intelligent machines as a “Third Realm” of Actors (robots) b. Intelligent machines “at Rest” (the Cloud and IoT)

Surprise: We are now entering the Epic Struggle for “Control and Access”, the exercise of “Cyber Power”, across the world of human, machine, & network.
Theory 1: Tech Change is three stage, and “late stage” changes are difficult

- **Early**: society exerts most influence. Change is relatively easy.

- **Middle**: momentum accumulates around the invention (e.g., capital, labor, political). Change is more difficult.

- **Late**: technology appears “beyond social control”, or “technology out of control”. Change all but precluded.*

- Change in “Late Stage” comes with difficulty
  - Fukushima stopped nuclear power trajectory in Japan
  - Can the same be said of educational trajectories?

Danger: momentum of Internet decisions 40 years ago and tendency of internet tech to concentrate $$$ and power

*See Paul David & his QWERTY essay; Langdon Winner; Thomas Hughes, among others
Theory 2: Human Perception, Thinking, and Action is integrating with digital tech...at a distance

- **Sensing**
  - Human Senses (sight, hearing, taste, feel, smell)
  - Machine sensing: (Radio, Radar, TV, now IoT)

- **Thinking**
  - Human Decision maker (brain)
  - Computer/Computation (early analog, now digital, AI/Cloud, DISTANCE EDUCATION and Machine Learning)

- **Acting**
  - Human body (limbs...walking, holding, etc)
  - Human-Machine integration (cars, planes, ships)
  - Machine (unmanned systems, robots, in Cyberspace, DISTANCE EDUCATION and Machine Learning)
Theory 3: Dual Macro Revolutions... macro revolutions are VERY disruptive

- As distinct from multiple, preceding and coincident micro-techno revolutions... the “Macro” revolutions are combinations of multiple technologies which create an entirely new, never before seen, structure of economic/social/military activity.
3a. Macro Revolution: Autonomous technology creates a ‘Machine Realm’ of Econ/Social/Mil Activity…

- In pursuit of S-T-A advantage, three Realms emerge over time…
  - 1st: Social-Human Realm
    - (apprx 10,000 BC -
  - 2nd: Integrated Human-Machine Realm
    - (apprx 1588AD (military field of action); 1700s (socio-econ, the Industrial Revolution))
  - 3rd: Autonomous Machine Realm (A.I. & intelligent machines)
    - (apprx 2014-??)
3b. Macro Revolution: Humanity’s Information Storage goes digital, at the Speed-of-Light transfer
3b. Knowledge Storage and Communication & Internet in 1969 ... the Cloud and Internet of Things (IoT) emerges
All three Realms of physical action as well as the Cloud/IoT can be attacked...

– 1\textsuperscript{st}: Social-Human Realm (est 10,000 BCE-
– 2\textsuperscript{nd}: Integrated Human-Machine Realm (est 1588-
– 3\textsuperscript{rd}: Autonomous Machine Realm (2014-

-Cloud/Internet of Things (IOT) (1969-

‘Cyber Power’ can be exerted across the Three Realms and the Cloud/IoT… resulting in a world of concentrating wealth, and contested ‘netted’ humans and machines
Some Recent Evidence of Accelerating Change

- Electronic/Computer systems under siege
  - Only 12 computer viruses in 1988; 2017, in the hundreds of millions

- Robotic Revolution
  - Countries producing or designing unmanned systems: 2001, <10; 2017, 80+

- Social Media a Disruptive Force
  - Middle East turmoil following a “Twittered” Arab Spring 2011; Ukraine 2013; U.S. election 2017

- Big Data/High Performance computing/AI
  - “Watson” beats the human in Jeopardy 2011
  - See MIRI literature (Machine Intelligence Research Institute)
A Tool and Framework for Thinking...
3a. Macro Revolution: Autonomous technology creates a ‘Machine Realm’ of Econ/Social/Mil Activity…

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Two Realms of socio-tech-economic activity... the Industrial Age we knew...

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

Integrated Realm

Social-Human Realm

Soc-Tech-Econ Activity...humans, human-machine teaming...
Two Realms Framework to University Campus

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

Integrated Realm

Social-Human Realm

Universities…human teams, human-machine teaming…
Apply Three Realms Framework to University Campus

Machine Realm

Role of Machine Factors in S-T-A Functions

Social-Human Realm

Social-Human Factors more decisive

Integrated Realm

Universities...human teams, human-machine teaming, and machine-to-machine teaming...
Third Realm of Robotics/AI emerges across economy and military…
A New Reality…3a. Three Realms of Physical Activity on the planet…Three Realms of Warfare

Machine Realm

Integrated Realm

Social-Human Realm

As before in history… DoD is often first to experience change…effects are spreading to civil society, biz, and education
Three Realms of Policing at Sea

- **Machine Realm**
- **Integrated Realm**
- **Social-Human Realm**

Role of Machine Factors in S-T-A Functions

*Machine Factors More Decisive*

*Social-Human Factors more decisive*
The Three Realms Applied to Industry (this case, Maritime)

- **Machine Realm**: More decisive factors
- **Integrated Realm**: Role of Machine Factors in S-T-A Functions
- **Social-Human Realm**: More decisive factors

©Hagerott 2014
Apply the Three Realms to Agriculture

Machine Realm

Integrated Realm

Social-Human Realm

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

Agricultural Workforces disrupted by mechanical industrialization... now happening with A.I.
Apply Three Realms Framework to Power Grid/Energy

- Machine Realm
- Integrated Realm
- Social-Human Realm

Keeping the lights on… humans, human-machine teaming, and machine-to-machine teaming…

©Hagerott 2014
Three Realms are redefining Manufacturing... lights out factories... Baxter builds Baxter??...

- **Machine Realm**
- **Integrated Realm**
- **Social-Human Realm**

**Role of Machine Factors in S-T-A Functions**

**Machine Factors More Decisive**

**Social-Human Factors more decisive**
Apply Three Realms Framework to University Campus

Machine Realm

Integrated Realm

Social-Human Realm

Universities...human teams, human-machine teaming, and machine-to-machine teaming...
3b. Knowledge Storage and Communication...Internet Growth...across all Realms of Activity and the Globe

Cyberspace comes into existence...But this global information entity becomes both a source of wealth and a target for Cyber Attack...
A New Reality…digital machines integrating with cyberspace (visual)

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

Global Information Grid Connects across all Realms

Cyberspace integrating with all Three Realms
Struggle for Cyber Power, control, and access

- National borders: Russian cyb-physical invasion of Georgia/Ukraine
- Defense forces: US Navy cyber safe; NK nuke arsenal
- National govt functioning: Estonia
- Personal info: OPM; ND govt
- Credit card transactions: Target Corp
- Banks: from Wall Street to local credit unions
- Transport: Chrysler hack
- Utilities: Shodan; Russian attack on Ukraine grid Dec 2015
- IoT: refrigs and baby monitors, home security; pace makers
- Research institutions: Penn state; Rutgers
- Social media: Twitter flash crash; FB attack (DDOS)
- Online identity and state of mind: Cornell FB study
- Energy Production: SHAMOON attack in Saudi Aramco

Cyber power alone destroys physical facilities...German factory... hospitals shut down in May 2017
Cyber Attack/Defense across the Three Realms (visual)

**Machine Factors More Decisive**

Role of Machine Factors in S-T-A Functions

**Social-Human Factors more decisive**

Cyber Security can be limited by lack of technology or workforce

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Cyber Attack/Defense across the Three Realms Applied to Industry (this case, Maritime)

- Machine Realm
  - Machine Factors More Decisive
  - Role of Machine Factors in S-T-A Functions

- Integrated Realm
  - Social-Human Factors more decisive

- Social-Human Realm

©Hagerott 2014
Apply the Framework to Agriculture

Machine Factors More Decisive

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Machine Realm

Integrated Realm

Social-Human Realm

CYBER PERVADESS ALL Realms...
Apply the Framework to Energy

Machine Realm

Integrated Realm

Social-Human Realm

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

Machine Factors More Decisive
Framework applied to Manufacturing... real factories, people, and machines integrating with the “Cloud”

Cyber (cybernetic) Knowledge required to create wealth and to protect privacy
Apply Three Realms Framework to University Campus

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

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Cyber (cybernetic) Knowledge required to create wealth and to protect privacy
Role for Higher Education…. The Most Unexpected/Unanticipated Challenge of our time?
Two Realms Framework to University Campus

Machine Factors More Decisive

Social-Human Factors more decisive

Integrated Realm

Social-Human Realm

Universities…human teams, human-machine teaming…
Bridging the gap between Human and Machine/Cyber Realm… requires STEM-C Education…

Machine Factors More Decisive

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

Gap between the Human and Machine and Cyberspace… education is the only way to ‘bridge the gap’. Moral equivalent of 1862 & Sputnik?
Bridging the gap between Human and Machine/Cyber Realm… requires STEM-C Education…

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Gap between the Human and Machine and Cyberspace… education is the only way to ‘bridge the gap’. Moral equivalent of 1862 & Sputnik?
EDUCATION EQUITY Challenge: Much of Rural/Post-Industrial America is being left behind as the Cyber Economy/Al Machine Economy Emerges… leaving some regions less prosperous and more vulnerable to cyber insecurity
High Speed Internet Regional Gap

High-Speed Internet Use by States

States in the West and Northeast have higher rates of high-speed use than states in the South.

Source: U.S. Census Bureau, 2014 American Community Survey.
Regional Gaps in Computer Science Degrees Awarded

Degrees Awarded by County for Computer Science Majors

Dataset: NCES IPEDS
Source: Department of Education
National Centers of Academic Excellence in Cyber Defense (CAE-CD)

The National Security Agency (NSA) and the Department of Homeland Security (DHS) jointly sponsor the National Centers of Academic Excellence in Cyber Defense (CAE-CD) program. The goal of the program is to reduce vulnerability in our national information infrastructure by promoting higher education and research in cyber defense and producing professionals with cyber defense expertise for the Nation.

CAE-CD Designations
- Four-Year Baccalaureate/Graduate Education (CAE-CDE)
- Two-Year Education (CAE-2Y)
- Research (CAE-R)

All CAE-CD Institutions are:
- Regionally accredited within the United States
- Leaders in Cyber Defense education and the development of the cybersecurity discipline
- Producers of cyber professional from mature programs

CAE-Cybersecurity Designated Institutions
- Map includes both institutions in the CAE-Cyber Defense and CAE-Cyber Operations programs.

For more information, visit: www.nist.gov/nice or contact: askCAEAE@nsa.gov
Cyber Security Workforce Activity Metric (Demand for labor)
(Ranges from as low as 85 openings for light gray, up to 45,000 for dark blue)

Figure (4)[1]

[1] Image derived from dynamic data sets available by collaborative effort of NICE and NIST. Go to http://cyberseek.org/heatmap.html
Neglect of Tribal Colleges… Regional and Socio-Economic…

The tribal colleges are almost all relatively young, established in 1970s, and thus lack endowments of any size, and also lack depth of curricular offerings in computer science or related STEM-C fields.

Figure 5: Distribution of Tribal Colleges of the U.S. [1]

What is needed? Purposeful action to seek equity during the Two Macro Revolutions

- More STEM-Cyber (STEM-C) education in outlying regions and lagging socio-economic groups…
  - K12
  - Undergrad and Graduate

- Knowledge Sharing between more mature Machine-Cyber Cultures/Silicon Valley and the outlying regions and lagging socio-economic groups …

- Business- Entrepreneurial Culture Transfer to outlying regions and lagging socio-economic groups …
Impediments or challenges

- AI Machine/Cyber Biz, Wealth, KSA (knowledge, skills, abilities) are concentrating not diffusing (see Ryan Avent, “Wealth of Humans” for exposition)

- Regional shortage of STEM-C Professors to generate new knowledge and prepare next generation.
  - Faculty models? Should we consider temporarily re-balancing faculty employment categories (eg., tenure track, adjuncts, fellowships) during a period of rapid change of knowledge/tech in critical fields?
  - Shortage of STEM-C K12 teachers in the state and regions…lack of competitive salaries? Brain Drain?
Impediments or challenges

- Cultural-Human Connections between Silicon Valley and rural regions are lagging, further impeding diffusion of cyberspace knowledge and culture
- Financial Resources to ‘re-tool’ K12 and Higher Ed?
  - Note: many of these outlying states and/or regions are in economic decline either absolute or relative.
Federal Gov’t losing interest in equity? Who can drive national/regional/state change... in time??

- President Obama HBC Comp Sci initiative: $25mil for 13 colleges?
- NSF/NICE/NIST: modestly funded but growing
  - NSA CAE is self funded from CYBERCOM budget??
- TEAL and other programs growing in popularity…
- Western Governors University, others?
- Multiple corporate efforts…
- Other initiatives in your states??? Georgia Cyber K-12

Who can help integrate across the nation? How to energize, empower, & fund state-regional-local STEM-C leaders and make connections to High Tech corridors?
2. State System Campus Security Challenge
Cyber-threats to Campuses

- Theft: Engineering Department in a leading East Coast university victim of Cyber attack… for two years.
  - Massive loss of Intellectual Property, research contracts at risk
- Denial of Service, both Online and On Campus instruction
  - Several days at a major university
- Ransom: “WannaCry” (RANSOMEWARE)…
  - Campuses in the Midwest compromised… hundreds of computers ‘locked out’ and data lost…

Are you comfortable with your knowledge, policies, procedures for what is happening at the intersection of Cyber Space and the Real Space of Campuses, IP, and Privacy of Students?
Cyber Security and Campuses: some facts

- Higher ed is commonly categorized as a Soft Target

- 14,000,000 email addresses/passwords belonging to U.S colleges available to purchase online in Dark Web.

- ...What’s worse: “the numbers are staggering and rising quickly,” the study reads.

- Few institutions have policy/staff to mitigate, detect, respond to, and rapidly recover from cyber-attacks.
Cyber Insecurity now a Board Issue

• Cybersecurity (Data Protection and Privacy) has moved from Tech to a CEO and Board-level business issue.

• Senior non-technical leaders (Chancellor’s, Board Members) may not understand the cyber threat, but nonetheless be held accountable if cybersecurity issues are not addressed successfully (e.g., TARGET Corporation board case study).
In the news most recently... Ransomeware

-Ransomware estimated to cost higher ed institutions over $250 per individual and total costs in the millions of dollars,
  - and untold direct and indirect damage to include brand damage
- Spring 2017 saw major Ransomeware attacks disable 100+ hospitals, multiple government institutions, to include college campuses.
RANSOMWARE...Courses of Action

Ransomware attacks have caused senior non-technical leaders to think through a number of clear options for recovery from a successful cyber-attack. The growing list of courses of action currently includes:

• pay the ransom
• don't pay the ransom and try to repair the damage
• do a "forklift" upgrade and replace the impacted computer system(s)
• do nothing

• Do your state policies allow payment of RANSOM? Is there equity in your state policies? What happens to less well funded campuses and student body if trends continue... the rich can pay, the less well off cannot?
WICHE initiative…

1. **STRATEGIC INTENT**: OPENLY STATE THAT CYBER-THREATS ARE AN ONGOING REALITY THAT COMPROMISES HIGHER EDUCATION’S MISSION; COMMIT TO DOING WHAT IS NECESSARY TO PROTECT HIGHER ED DATA ASSETS.

2. **OPERATIONAL GUIDELINES**: CREATE AND SUSTAIN A CULTURE OF SECURITY ACROSS THE HIGHER ED COMMUNITY OF INTEREST.

3. **TACTICAL EVENTS AND TIMELINE**: IN 2017 DESIGN/IMPLEMENT AND ACTIVELY SUPPORT INITIATIVES THAT STRESS A THREE TIERED CYBERSECURITY STRATEGY FRAMEWORK
   - **TIER 1** - INDIVIDUAL RESPONSIBILITY
   - **TIER II** - INSTITUTIONAL/SYSTEM RESPONSIBILITY
   - **TIER III** - STATE RESPONSIBILITY
WICHE/DHS/FEMA HIGHER EDUCATION SENIOR LEADER EXERCISE PILOT

a. Based on a request from DHS/FEMA to regionalize traditional Cyber-exercises

b. WICHE modified the plan to focus on senior non-technical higher ed leaders in each WICHE state

c. States cover only travel costs to a central site for state participants (use regularly scheduled meetings)

d. North Dakota stepped up to be the first WICHE state to participate

e. Fifteen (15) WICHE states are participating one at a time over a 3 year period

Year I – Tabletop exercise delivered face to face to all Presidents/Chancellors in each state

Year II – Exercises delivered in a hybrid (f2f and Internet) to the Presidents/Chancellors

Year III – Exercises delivered via Virtual Reality to all Presidents/Chancellors
WICHE POINT OF CONTACT

• Mike Abbiatti, Vice President, Education Technologies WICHE/ Executive Director WCET
• E-mail: mabbiatti@wiche.edu
• Voice: 479.856.2413
• Video: Hangouts, Skype, Go to Meeting
• Physical Address: 3035 Center Green Drive, Suite 200, Boulder, CO 80301
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Overall Summary

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  - Intelligent Machines/AI at Rest, “The CLOUD” & IoT.
- Tech/Education Leaders have three tasks: C^3
  - Create the Technology, it is a competitive race (e.g., robots, routers, internet art, businesses, services)
  - Civilize the Technology (eg., law, policy, sociology, …. Leaders in these fields must all shoulder a load)
  - Control and Access the Technology (the Cybernetic (Cyber) challenge)

State Higher Education Systems have key role to play… for the common good.
Video, Chinese DDOS attacks on FB:
https://www.youtube.com/watch?v=efmJsENgG-o
Disrupting How We Provide Security and Policing at the intersection of our virtual and physical lives...
Grappling with a Framework/Theory

A Future in Denial
Slate Magazine
Disrupting how we control and Extract, Convert, and Distribute Energy
Summary: Confluence of Two Macro Techno-Revolutions will Challenge most everything….

- Two near simultaneous challenges:
  
  1. Emergence of a Third Realm: Autonomous intelligent machines moving in physical space (note: the older ‘Realms’ of Social-Human, and Integrated Human-Machine exist, too)

  2. Electronic Netting of the World of Humans and Machines…Machine intelligence “at rest”.

- The Big Surprise: Battle for Control of the Machines and of Information… the ‘Cyber’ battle…made harder by the previous techno-momentum of past 40 years.
• Using the Military Example of Evolution of Sense-Think-Act over time.
• This also applies to other sectors of society, economy, technology (e.g., agriculture, energy, transportation, etc)
One Realm of warfare….‘Social-Human’ factors dominate Sensing-Thinking-Acting

Social-Human Factors Dominate S-T-A

Enter Accelerating Technological Innovation, Increasing Complexity, and the more tools to better Sense-Think-Act (S-T-A)
Waves of Innovation increases Human-Machine S/T/A integration in war...evolving the 2\textsuperscript{nd} Realm

Increasing Role of Machine Factors in S-T-A Functions

Integrated Realm

Social Human Realm

1400-1500s: Gunpowder, magnetic compass...shift between Lepanto and Armada 1588

500-300 BC: Catapult and Galley

Pre-Industrial Age | Industrial Age | Information Age and ??

Time (not to scale)

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“Integrated Realm” emerges…Machines and specialists replace human mass…first at sea

Social-Human Realm: 1571 Battle of Lepanto dominated by mass infantry battles fought on/across fleets of galleys….

To Integrated Realm: 1588 Battle of Armada the English embark ZERO INFANTRY and fight an artillery duel at sea on ‘ships of the line’
Waves of micro-Innovations… create an Integrated Realm of human & machine on Land and in the Air

Pre-Industrial Age  Industrial Age  Information Age and ??
Time (not to scale)

Increasing Role of Machine Factors in S-T-A Functions

Social Human Realm

1400-1500s: Gunpowder, Lepanto, and Armada 1588

500-300 BC: Catapult and Galley

1840-1860s: Ironclad steam ship, Telegraph communications

WWI: Tank, Aircraft

WWI: Dreadnought, Submarine
Unclassified

Human & Machine team up to create “Integrated Realm” of war, but confused leaders produce disaster of WWI

“Artillery men with their cold blooded mathematics seemed subversive of all that made a soldiers life heroic, admirable, worthy.” William McNeill,

Pursuit of Power}
Now...two Realms of warfare co-exist...

Increasing Role of Machine Factors in S-T-A Functions

Integrated Realm

Social- Human Realm
With the increased complexity came an increased machine capacity for sensing, thinking, acting at higher speeds…the ‘MACHINE Realm’ emerges.

“…modern warfare is more a matter of machines than of men.” Thomas Edison, 1913
Micro-waves of Innovation push into the Third Realm of Autonomous and Ambulatory Machines…

**Pre-Industrial Age**

- 500-300 BC: Catapult and Galley

**Industrial Age**

- 1400-1500s: Gunpowder, Lepanto, and Armada 1588
- 1840-1860s: Ironclad steam ship, Telegraph comms
- WWI: Tank, Aircraft
- WWI: Machine Gun, Submarine
- Cold War: SAGE/AEGIS air def system

**Information Age and ??**

- WWII: V1/2, ENIAC
- 2001: armed UAV
- 2014: armed autonomous vehicle?
A New Reality… Three Realms of Physical Activity on the planet…Three Realms of Warfare

Role of Machine Factors in S-T-A Functions

Social-Human Factors more decisive

As before in history… DoD is often first to experience change…effects are spreading to civil society, biz, and education
Future Study Topic: For social scientists...the Urgent Need for Resilient, Morally-Ethically Grounded Youth

- The most advanced information infrastructure in history... but does it convey truth to our youth?
- What happens to the young when their value frameworks are disrupted... “Anomie”...
Gain Perspective: step back and look at the historical trajectory/trend of technology…. 

“... because our teachers …focus their attention only on the present or at the most on the very recent past, they find the present more and more difficult to explain. They are like oceanographers who refuse to look at the stars because they are too remote from the sea, and consequently are unable to discover the causes of the tides.” Marc Bloch, French historian and veteran of WWI and WWII, tortured and killed by the Gestapo while fighting as part of the French Resistance.