Committee on Revitalizing Graduate STEM Education for the 21st Century and The Next Generation Research Initiative

Bold Visions for the Future of Science
NAE: Statement of Task

- How will disruptions to institutions of higher education and the workforce affect the system of graduate education, academic research (notably in the biomedical sciences), and research for industry? Are there particular nuances that may apply more readily to fields such as engineering and computer science than the other fields in STEM?

- How will the increasing rate of change in technology affect skills development and knowledge acquisition for STEM graduate students? For postdocs and early career faculty? What implications will it have on lifelong learning? If you were a member of these committees, what recommendations would you make and to whom would they be targeted?

“Investigate the many new initiatives and models that are influencing graduate education, including MOOCs, other digital learning programs, increasing numbers of alternative providers of master's and Ph.D. degrees, and opportunities to secure credentials through multiple sources”.

Layne Scherer, Study Director, Committee on Revitalizing Graduate STEM Education for the 21st Century, Program Officer, Board on Higher Education and Workforce The National Academies of Sciences, Engineering, and Medicine
Gutenberg to Zuckerberg: Exponential Information and Complexity

Information Doubling Curve
Buckminster Fuller
https://www.bfi.org/

“Jobs today are changing as rapidly as technology does”

IoT Tipping Point
Post-Information Age
Low barriers to markets, talent and information

Information Age
Computerization – digital data

Industrial Revolution
Industrial production

1440 -1900
Knowledge doubled in 400 years

1900-1950
Knowledge doubled in 50 years

1950-1970
Knowledge doubled in 20 years

1970-1980
Knowledge doubled in 10 years.

1980-2000
Knowledge doubled in 8 years.

2017
Knowledge is doubling every 13 months.

2020
IBM predicts the build out of the “internet of things” will lead to the doubling of knowledge every 12 hours.

“Knowledge doubled in 400 years
1950
Knowledge doubled in 20 years
1970
Knowledge doubled in 10 years.
1980
Knowledge doubled in 8 years.
2017
Knowledge is doubling every 13 months.”

“Jobs today are changing as rapidly as technology does”

“The Ages of our civilization evolve slowly and with incredible resistance, displacement ends as information adoption rates reach a tipping point.”
Information is created at an **exponential rate** every day

People require access to very **specialized information at particular instances** in time

Everybody learns differently

Requires neuroscientists, educators, statisticians, digital data designers, learning scientists, instructional designers, big data experts, etc.

“In recent years, a growing appreciation of individual preferences and aptitudes has led toward more “**personalized learning**,” in which instruction is tailored to a student’s individual needs”. NAE 2017

The Rise of Micro certificates

The Internet makes information and media available at the click of a button

Mobile connects nearly everyone 24x7

Cloud computing provides cheap, practically infinite computing power

Note: Hard economic times and advancements in job skills + learning technology can be an impetus for retraining which may explain some of the rapid growth in the five years spanning 2007-2014.

"the number of certificates awarded has skyrocketed more than 800 percent over the past 15 years."

Source: Calculations from IPEDS data, NCES population of institutions. 

By The Numbers: MOOCs-SPOCs in 2016

Top five MOOC providers by registered users:
1. Coursera – 23 million
2. edX – 10 million
3. XuetangX – 6 million
4. FutureLearn – 5.3 million
5. Udacity – 4 million

edX Mission: Increase access to high quality education, enhance teaching and learning on campus and online, and research how online learners learn.

Case Study: EdX MIT – Boeing – NASA Partnership

Professional Education in Architecture and Systems Engineering: Models and Methods to Manage Complex Systems

Small Private Online Certificate SPOC

The purpose of the micro – certificate is to grow the system engineering and modeling competencies of Boeing - NASA engineers (including all design centers and partners).

- On-line format, Basic to Intermediate SE KSA development
- Addresses structural (academic – industry) KSA alignment (i.e., industry relevant)
- Scalable enterprise delivery structure (supports all design centers)
- Responsive to space and brick and mortar instructor led constraints
- Cost effective
- Earns CEU’s (LTP funded)
- Improves retention (skin in the game)
- Potential matriculation towards accredited degree (with prerequisite)
- Ability to serve non-traditional populations (public audit intro course for free)
- Changes role of SME and faculty, guide on side vs. lecture and drill model
- Provides click stream data analytics, who – what – where -how

This certificate represents a new form of micro credential that blend industry (practice) with traditional academic (theory) i.e., employee competency based credentials.
The relationships between learning technologies, learning science research, educational psychology, and theories of instructional design are complex, more like an interacting ecology of ideas and practices than a clear hierarchical structure-organization.
Personalizing learning experiences: Machine learning - Characterization

- The concept of coupling data between agents (learners) and the system structure (school or industry) with real world behavior enables us to see (through the interaction patterns, agent sensing, acting and learning optimizing)

- Individual mouse clicks of each student accessing an online simulation, amount of time spent viewing a screen of information, each answer to each multiple-choice question on a survey, and terms entered into search boxes.

- These data uncover the distributive cognition of the social network, uncovering “The ghost in the machine” where thoughts are embodied in the agent actions.

Learning - particularly using technology - is largely content centric
Linking student performance and authenticity via on-line platforms, is achievable thru automated learning technologies.

Source: Dr. George Siemens, (2014)
Leverage Big Data and Learning Analytics to uncover the expert cognitive streams

“Learning analytics is the measurement, collection, analysis and reporting of data about learners and their context, for purposes of understanding and optimizing learning and the environments in which it occurs (SOLAR, 2010)
We are living in an age obsessed with intelligent systems. All walks of life are being transformed by innovations in machine learning, by software platforms that amplify human ability (from Mathematica to LinkedIn), improving online educational opportunities (MOOCs), and unprecedented access to the collective insights of globally dispersed communities of researchers and data sets (Wikipedia, Stack Exchange). These facts are changing both science and business. SFI Action Business Network
The relationships between educational systems, learning technologies, learning science research, educational psychology, and theories of instructional design are complex, more like an interacting ecology of ideas and practices than a clear hierarchical structure-organization.

Objective 1: Build a network of transdisciplinary complexity though leaders to address the significance challenges inherent in adaptive networked learning including learning science, network theory and research to practice.

Objective 2: Explore the cognitive and sociocultural factors related to the new labor economy, evolving demographics and advancements in cyber-physical data rich complex learning ecosystems.

Objective 3: Explore concepts and methods of this evolution through a complexity lenses including the analytical, theoretical and methodology dimensions of data collection within a complex sociotechnical system.

Objective 4: Holistic – Transdisciplinary educational opportunities: Consider transdisciplinary teaming research models that expose students to collaborative research.

Objective 5: Consider funding for alternative credentialing models; for example: Low-cost, High quality and relevant to workforce certificates and Micro-Masters (Technical – Business - Soft skills)

Objective 6: Explore alternative future and life long learning (a 40 year relationship instead of a 4-6 year relationship) including the creation of lifelong learning profiles, mapping of competencies, and building education – workforce models to anticipate future labor market knowledge needs.