Metropolitan Policy Program
at BROOKINGS

Defining and Analyzing the STEM Economy

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MA STEM Smart
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Overview

1) Why we need a new measure of the STEM labor force and what that looks like

2) Analysis of labor market based on such a definition

3) How to boost STEM education

Problems with Current Definitions of STEM Occupations

1. No agreement among federal agencies

- The NSF uses “Science and Engineering” labor force which roughly corresponds to occupations common to workers with a bachelor’s degree in science or engineering fields.
- 2012 BLS task force and Dept of Commerce use variations of this definition

2. Arbitrary standards.

- Not based on knowledge or skill requirements
- Not based on R&D activity
- Professional researcher bias?

New Brookings definition of STEM

A STEM occupation is one that requires an extraordinary level of knowledge in one or more core STEM fields.

Based on data from O*NET (Dept. of Labor project)

Advantages over conventions definition include: rigor, alignment with educational curricula, self-correcting, objective

For background on O*NET see: National Research Council Panel to Review the Occupational Information Network (O*NET), "A Database for a Changing Economy: Review of the Occupational Information Network (O*NET) (Washington: The National Academies Press, 2010); Norman Peterson and others, "Understanding work using the Occupational Information Network (O*NET): Implications for practice and research," *Personnel Psychology 54* (2) (2001), 451–492.

The Six Core STEM Domains in O*NET Knowledge Survey and Their Survey Anchors

Least Knowledge =1 → Highest Knowledge = 7

Scales for Science (Physics, Chemistry, Bio), Computers, Engineering, and Math

Computers and Electronics		
1	3	6
Operate a VCR to watch a pre-recorded training tape	Use a word processor	Create a program to scan computer disks for viruses

Composite STEM Score $_{o,k}$ = E [(Raw Score $_{o,k}$) - (Mean Score) $_{o,k}$]

Does this ONET Method Work?

1. High Correlation with occupational median wages—from 2012 BLS OES:

- Correlation is 0.56 for STEM Score vs. 0.36 for NSF Science and Engineering binary variable

2. High Correlation with occupational knowledge—taken from ACT Work Keys scores, aggregated by occupation:

- Correlation with ACT composite score is 0.67 for STEM score vs 0.52 for NSF

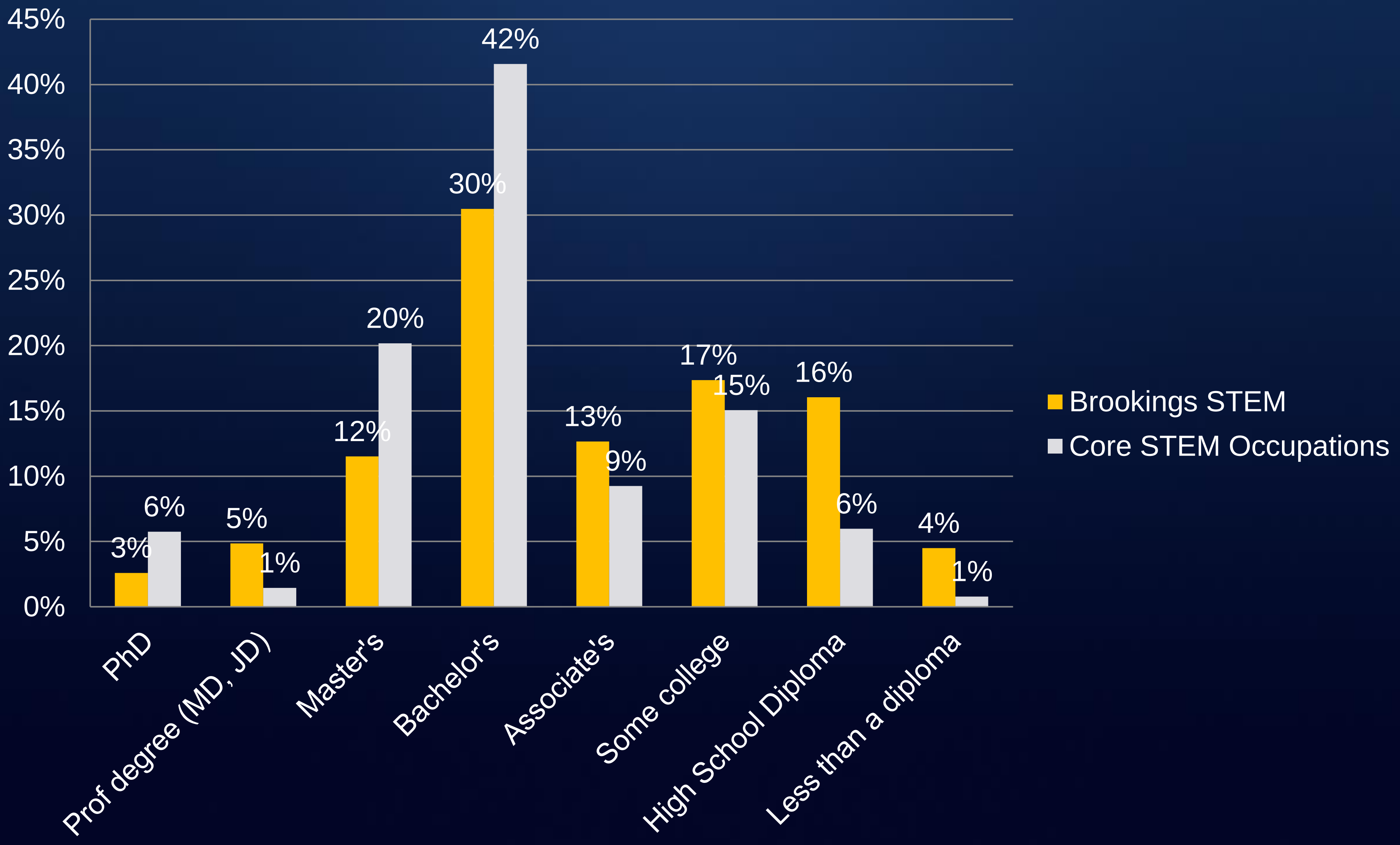
- Correlation with ACT math score is 0.57 for STEM Score vs 0.47 for NSF. Math knowledge score correlation is 0.64; Economics and finance is 0.39; Law knowledge score is 0.31 English knowledge score is 0.31

Major Occupational Categories Sorted by STEM Score, with Share of Jobs that are STEM, and Share of U.S. STEM Jobs, 2011

	High-STEM, Percentage of Jobs	**Share of U.S. High-STEM Jobs**
Architecture and engineering	100%	9%
Life, physical, and social science	87%	4%
Healthcare practitioner and technical	76%	22%
Computer and mathematical science	100%	13%
Installation, maintenance, and repair	53%	10%
Management	27%	6%
Construction and extraction	40%	8%
Education, training, and library	9%	3%
Business and financial operations	42%	10%
Farming, fishing, and forestry	8%	0%
Production	23%	7%
Arts, design, entertainment, sports, and media	16%	1%
Sales and related	0%	0%
Legal	0%	0%

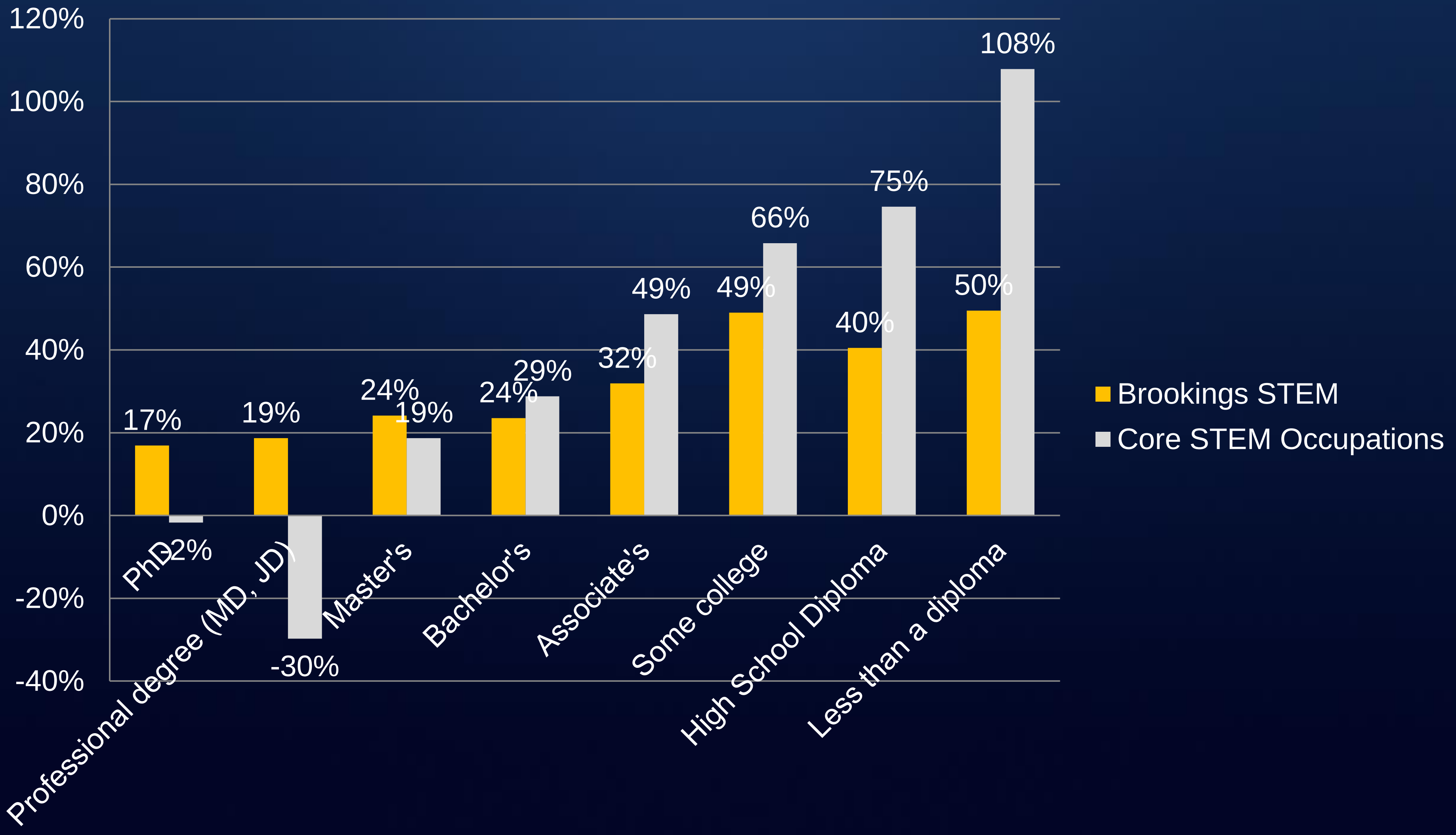
Source: Brookings analysis of O*NET and OES, 2011.

Educational Attainment of Workers in Brookings STEM Occupations and Core NSF STEM Occupations, 2012



Source: Brookings analysis of O*NET V18 and 2012 American Community Survey, via IPUMS. Core STEM occupations are: Computer and Mathematical occupations, Life, Physical, and Social Science Occupations, and Architecture and Engineering Occupations, all defined at 2-digit SOC level.

Within-Education Group Earnings Premium for Brookings and NSF-defined STEM Workers by Educational Attainment, 2012



Source: Brookings analysis of O*NET V18 and 2012 American Community Survey, via IPUMS. Core STEM occupations are: Computer and Mathematical occupations, Life, Physical, and Social Science Occupations, and Architecture and Engineering Occupations, all defined at 2-digit SOC level. Premium calculated as average earnings for workers of any age in each STEM-educational cohort divided by U.S. average earnings for all workers in the educational group less one.

Literature on Sub-bachelor's STEM contribution to innovation

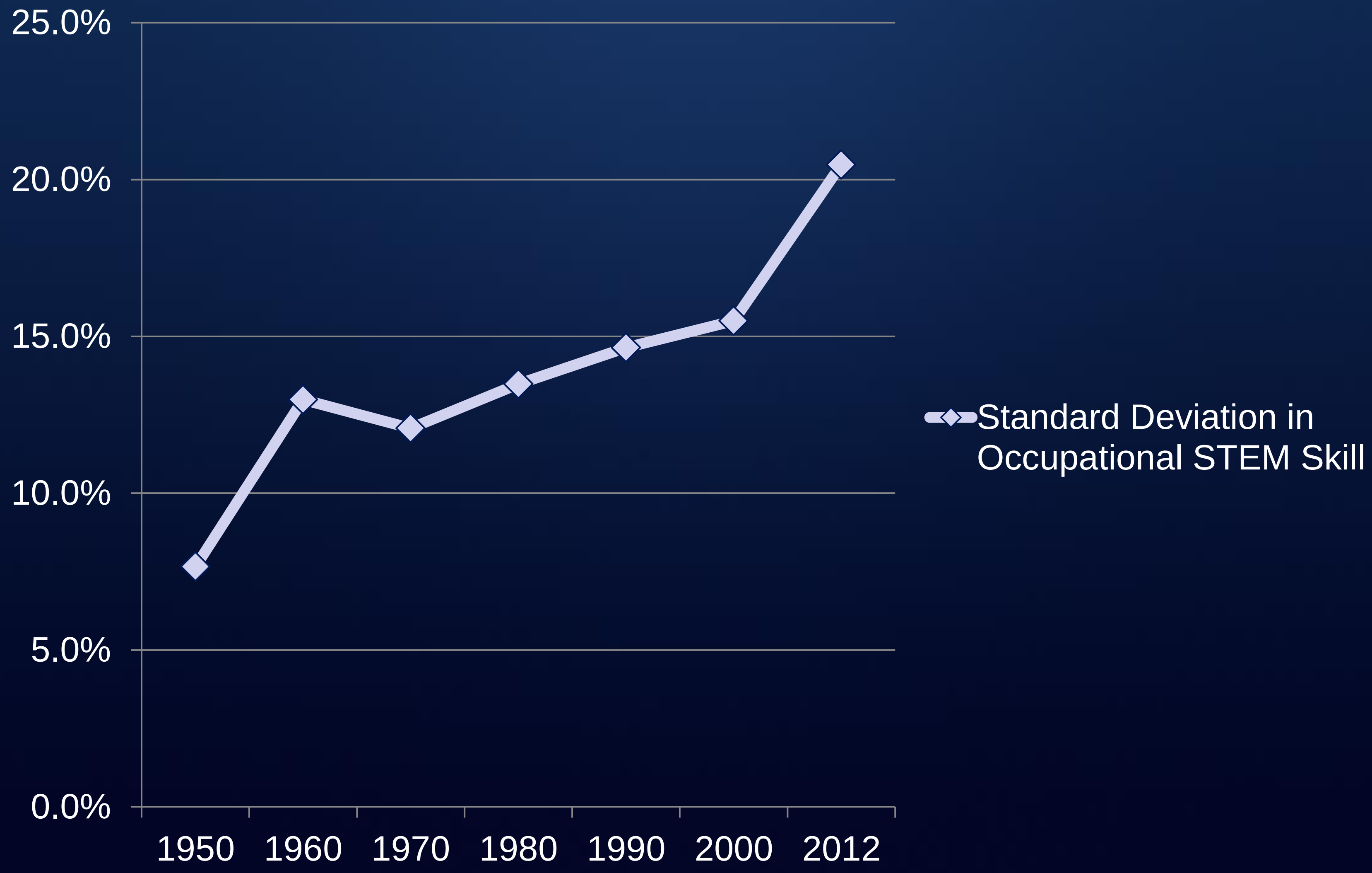
During industrial revolution:

Ross Thomson, *Structures of Change in the Mechanical Age: Technological Innovation in the United States, 1790 to 1865* (Johns Hopkins University Press, 2009);
Kenneth L. Sokoloff and B. Zorina Khan, "The Democratization of Invention during Early Industrialization: Evidence from the United States, 1790-1846," *Journal of Economic History* 50(2) (1990): 363-378;
Jacob Schmookler, "Inventors Past and Present," *Review of Economics and Statistics* 39(3) (1957): 321-333.

Presently in terms of lower product defects, higher capacity utilization and efficiency, and R&D quality:

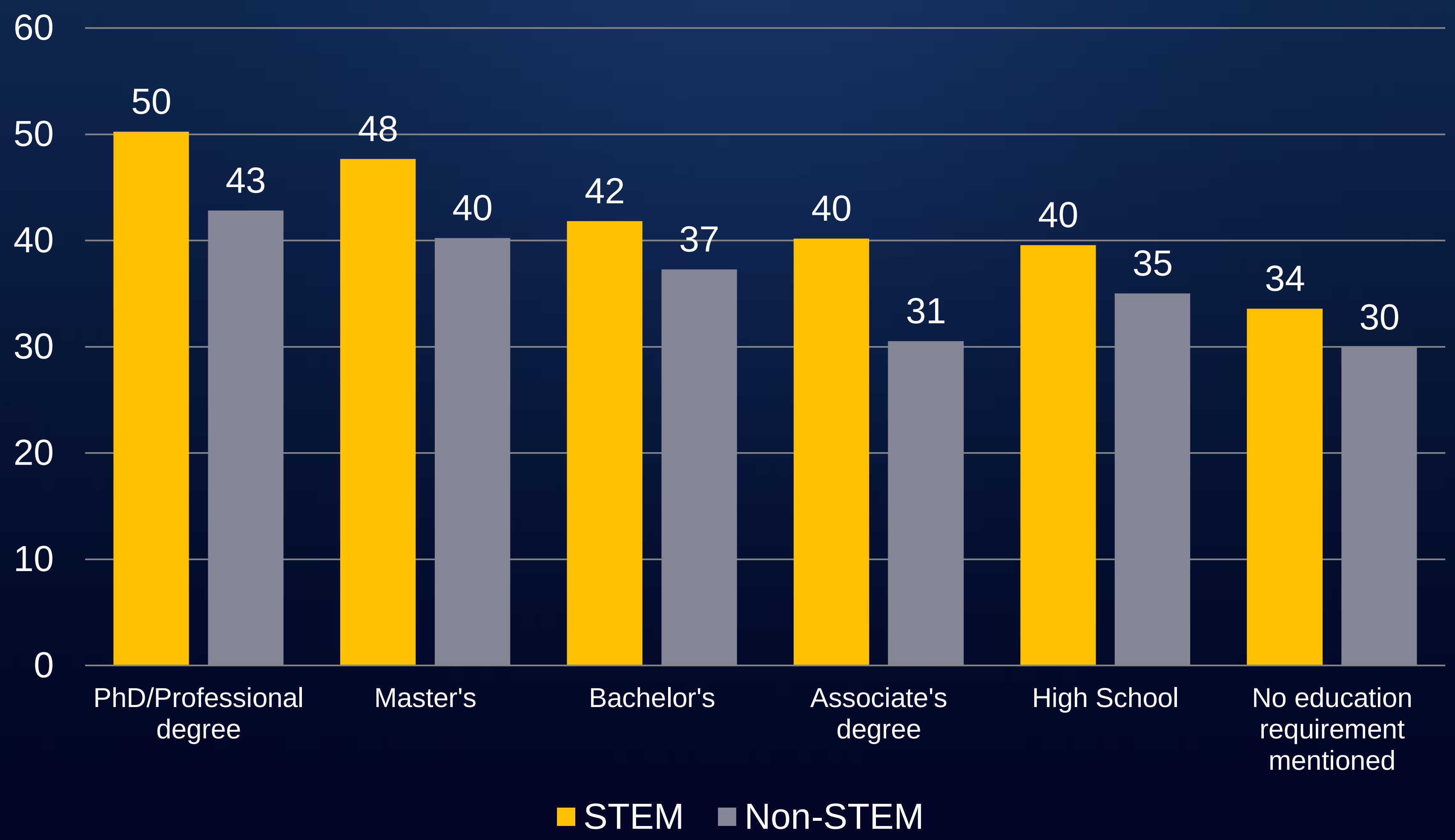
Philip Toner, "Workforce Skills and Innovation: An Overview Of Major Themes In The Literature" (Paris: OECD, 2011)

Wage Premium for STEM Skills, Controlling for Experience, Education, and Sex, 1950-2012



Analysis of data from Census Bureau via Integrated Public Use Microdata Series and O*NET. For methods, see Jonathan Rothwell, “Hidden STEM Economy,” (Brookings Institution, 2012).

Average Duration of Job Advertisements by Required Education and STEM Knowledge, 2013-Q1



Source: Brookings analysis of 1.1 million advertisements, using data from Burning Glass. Educational requirements are the minimum listed on the advertisement. Most occupations in the no education requirement category typically require at least a bachelor's degree in the STEM category but only a high school diploma in the non-STEM category.

How to boost STEM Skills

The to-do list

1) Enrich infant/toddler home life
2) Improve pre-K to 10th grade quality across the board
3) Allow students to take post-secondary level classes during last two years of high school
4) Lower cost of college and adopt best practices in retention and completion in higher-education
5) Expand access to adult training & improve curriculum alignment with demand

Who Needs to do it

1) Local governments via school, housing, and welfare policies
2) State governments via education, higher-education, training, and welfare policies
3) The Federal government via NSF, TAACCCT, H-1B Grants, tuition subsidies
4) Non-profits and Higher Ed via family support, tutoring, mentoring, tuition assistance and innovation
5) Businesses via philanthropic investments, apprenticeships, internships, and on-the-job training

Enriching infant-toddler care

Why does it matter? See Paul Tough's *Why Children Succeed*

What can be done: Nurse Family Partnership and other family intervention programs increase educational/cognitive performance, decrease unplanned pregnancies, and decrease child abuse and neglect.

http://toptierevidence.org/programs-reviewed/interventions-for-children-age-0-6/nurse-family-partnership

Improving quality of pre-K to 10th grade

What can be done:

1) High quality competition via vouchers and charter schools

2) A lottery system to allow parental choice, with voucher available for those who lose the lottery

3) Injecting best practice reforms from high-performing charters into low performing schools (see Roland Fryer and Will Dobbie’s work)

3) Paying teachers based on merit, not just seniority

4) A free market for housing: De-segregating housing by removing local zoning barriers to multi-family or more affordable housing in affluent neighborhoods

*More than a dozen quasi-experimental studies have proven 1-3

Junior/Senior year of High School as early college

What can be done:

1) New York City: IBM’s P-TECH

2) Chicago: Early College STEM Schools (partnerships with Motorola, Verizon, Microsoft, IBM, and Cisco)

2) Virginia Beach Public Schools’ Advanced Technology Center

3) Texas: T-STEM (Texas STEM schools)

4) Virginia: Governor’s STEM Academies

5) Nashville STEM academies

Lowering Costs and Adopting Best Practices in Higher-Ed Completion

What can be done:

1) CUNY ASAP (Accelerated Study in Associate Programs)

a) 51% 3-year graduation rate compared to 16% nationally
b) features include no cost beyond loans/aid; tutoring; block scheduling

2) University of Maryland Baltimore County Meyerhoff Scholarship Program & M-STEM at Michigan

3) Lower the cost of college

Universities should partner with businesses to make on-line learning lead to industry credentials, even if not degrees

Expand Training and Align Curricula with Demand

What can be done:

1) Community colleges can and often do work directly with businesses and business organizations to insure relevancy of course work and high placement rates of students

Workforce intermediaries can help. Example: Biowork in North Carolina. See Nichola Lowe, Harvey Goldstein and Mary Donegan, "Patchwork Intermediation: Challenges and Opportunities for Regionally Coordinated Workforce Development," *Economic Development Quarterly 25 (2011): 158-171*

2) States and the Fed government can increase funding for adult training programs and relax restrictions on unemployment insurance enrolling in training programs

For more information

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Explore recent research:

The Hidden STEM Economy
http://www.brookings.edu/research/reports/2013/06/10-stem-economy-rothwell