Henry Edwin Sever Institute

Washington
University in St.Louis

SCHOOL OF ENGINEERING
& APPLIED SCIENCE

Preparing Millennials for Technology, Team, and Data Complexity

How to teach SE to non-SE majors

PRESENTATION FOR INCOSE MIDWEST GATEWAY CHAPTER

Dr. M Malast   **1/18/18**

INTRODUCTION

Photo: medicine.wustl.edu

- Background
  - ➢ Higher Ed challenge
  - ➢ Millennials characteristics
- What's at stake for stakeholders?
  - ➢ College grads get nearly all jobs
  - ➢ Higher Ed evolving due to technology, globalization
- Teaching Systems Engineering (SE) to Non-SE majors
- Conclusion

BACKGROUND

HIGHER EDUCATION CHALLENGE
MILLENNIALS CHARACTERISTICS
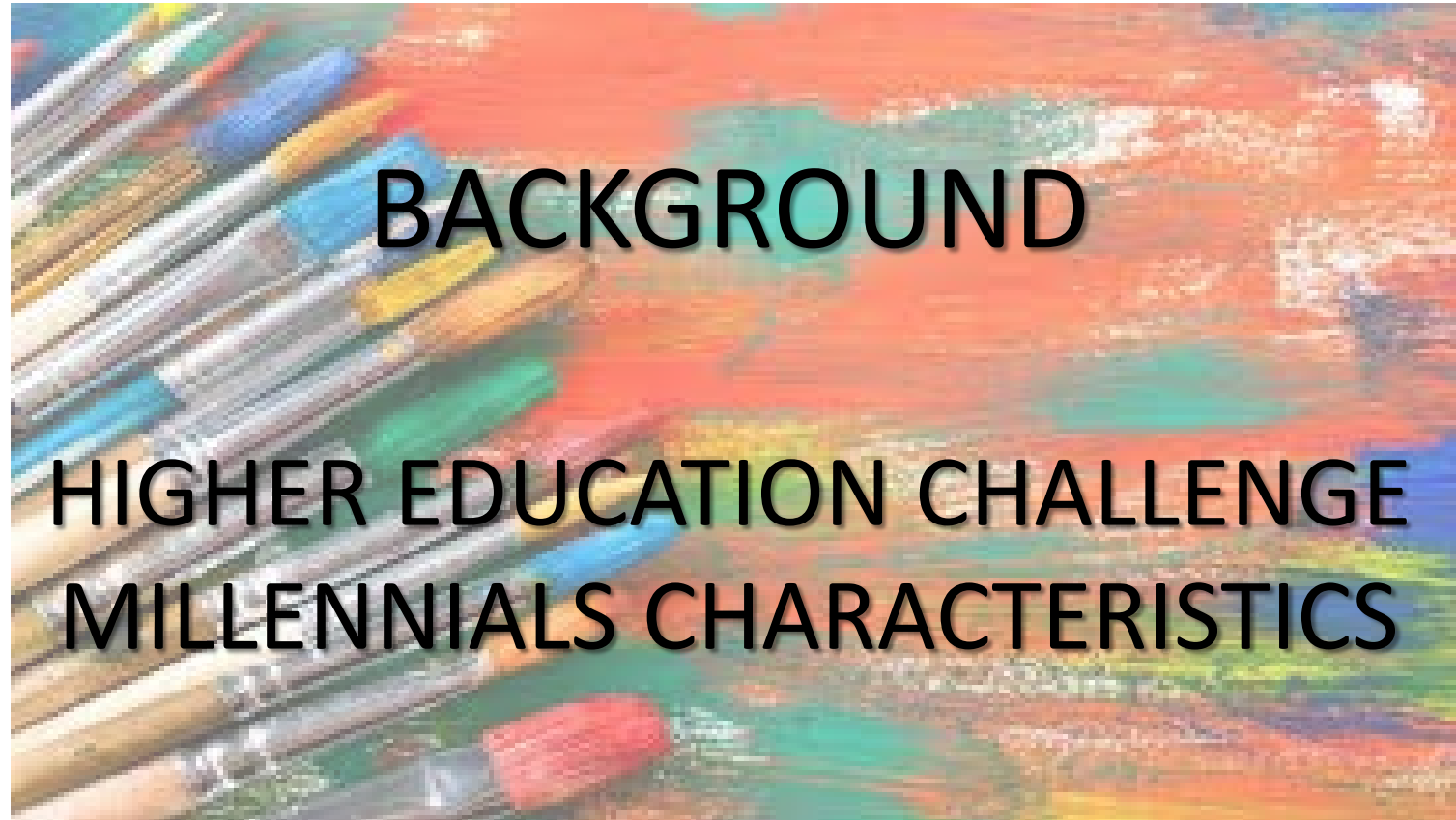
HIGHER EDUCATION CHALLENGE

Competition – commerce of digital world

- 1.40 billion people in China

- 1.30 billion people in India

  ➢ 0.34 billion people in U.S.

*Outgunned? U.S. needs a smarter, more creative workforce to retain competitive advantage*

Contributor, Judd Gregg opinion. "Judd Gregg: Prioritize brains over bridges." *TheHill*, 15 Jan. 2018, thehill.com/opinion/education/368929-judd-gregg-prioritize-brains-over-bridges.

Education Level of Individuals by Age Group, 2015
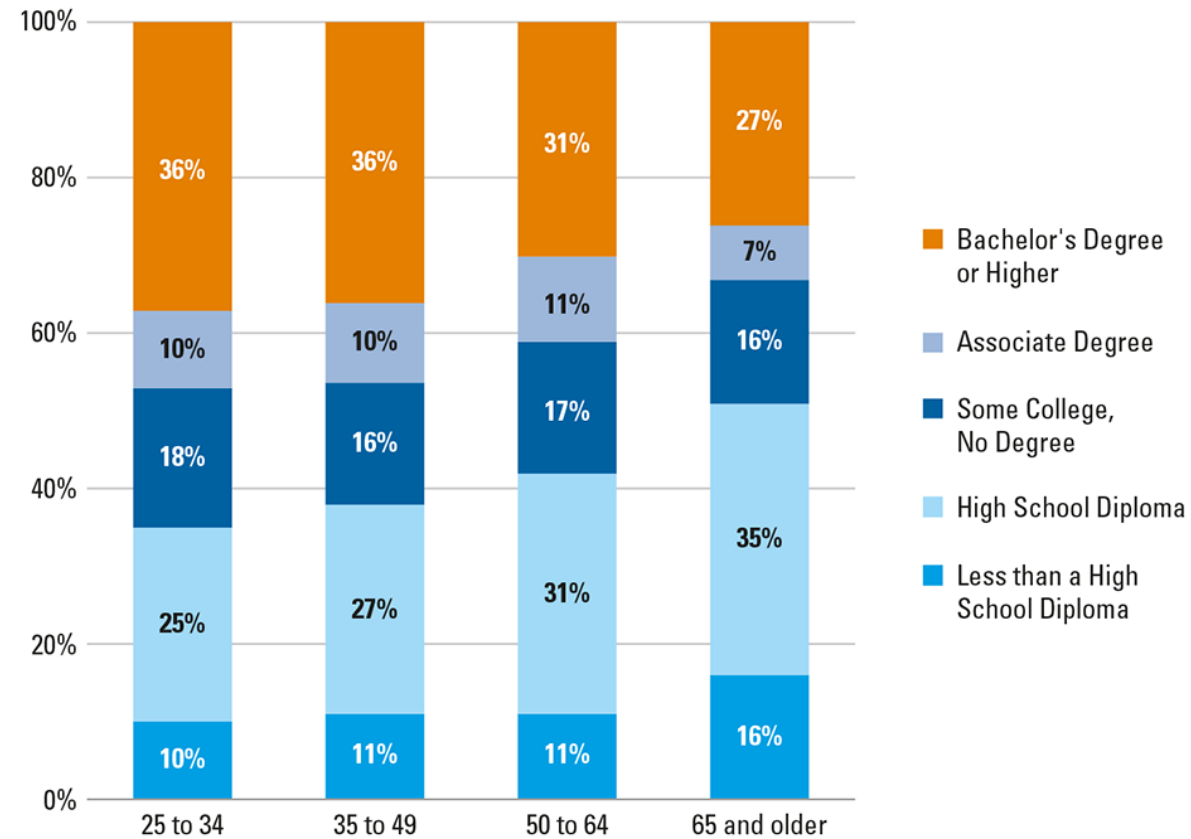
SOURCE: The College Board, *Education Pays 2016,* Figure 1.5B

Postsecondary Enrollment Rates of the High School Class of 2011-12 and Percentage of All Adults with at Least a Bachelor's Degree in 2014
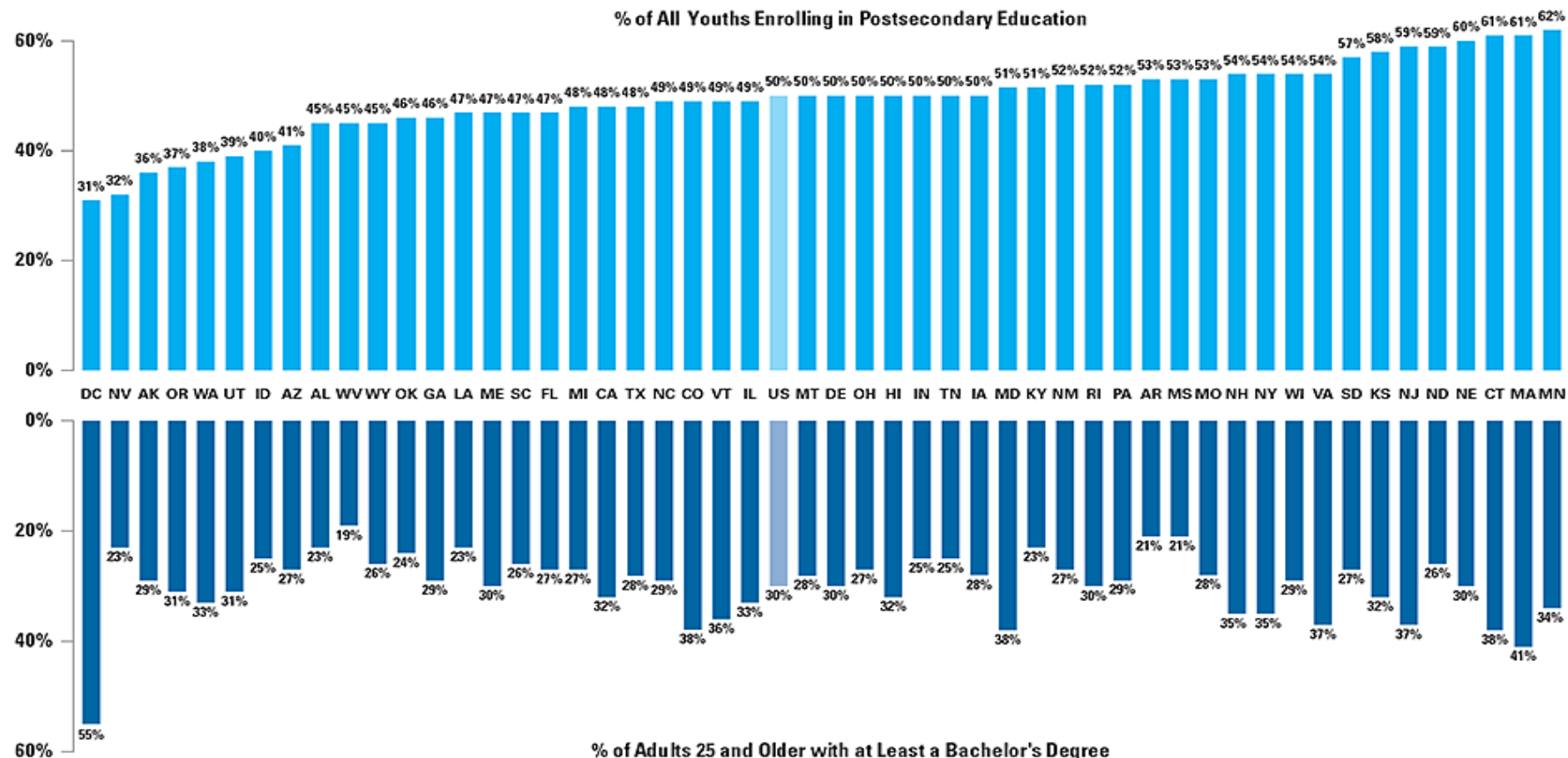
SOURCE: The College Board, *Education Pays 2016,* Figure 1.7

HIGHER EDUCATION CHALLENGE

Provide employers with job candidates who

- Possess tech and soft skills, strong work ethic
- Life-long learners with strong team skills

Employers need qualified job candidates

- Science, Technology, Engineering, and Mathematics (STEM) positions hardest to fill with qualified candidates

HIGHER EDUCATION CHALLENGE

Provide Millennial students with

- Affordable education
- Teaching excellence
- Marketable degree options

Students want best shot at job market entry into global economy

- STEM majors are popular

HIGHER EDUCATION CHALLENGE
UNIVERSITY BUSINESS MODELS

- Are students the customer? Are parents? Employers?
- If students are customer,
  - ➢ How do motivate your customer to work hard for you?
  - ➢ Do you risk displeasing your customer – grades, etc.?
  - ➢ Market focus – lazy rivers, i.e. LSU

Source: Photo tweeted by LSU

Like Congress, (some) universities hand future generations the bill for boondoggles.

Riley, N. (2018). *LSU's 'Lazy River' and the Student-Fee Sham*. [online] WSJ. https://www.wsj.com/articles/lsus-lazy-river-and-the-student-fee-sham-1513381917 [Accessed 15 Jan. 2018].

HIGHER EDUCATION CHALLENGE – GROWTH VS. FIXED MINDSET

People's self-theories about intelligence have a profound influence on their motivation to learn.

- **Fixed theory of intelligence** – Students concerned with being smart, doing well, avoiding mistakes, and not looking dumb.

- **Growth theory of intelligence** – students want challenge, increase abilities independently, take risks, not afraid to fail.

Source: "Fixed versus growth intelligence mindsets: It's all in your head, Dweck says." Fixed versus growth intelligence mindsets: It's all in your head, Dweck says | Stanford News Release, 7 Feb. 2007, news.stanford.edu/pr/2007/pr-dweck-020707.html.

BACKGROUND

HIGHER EDUCATION CHALLENGE
MILLENNIALS CHARACTERISTICS
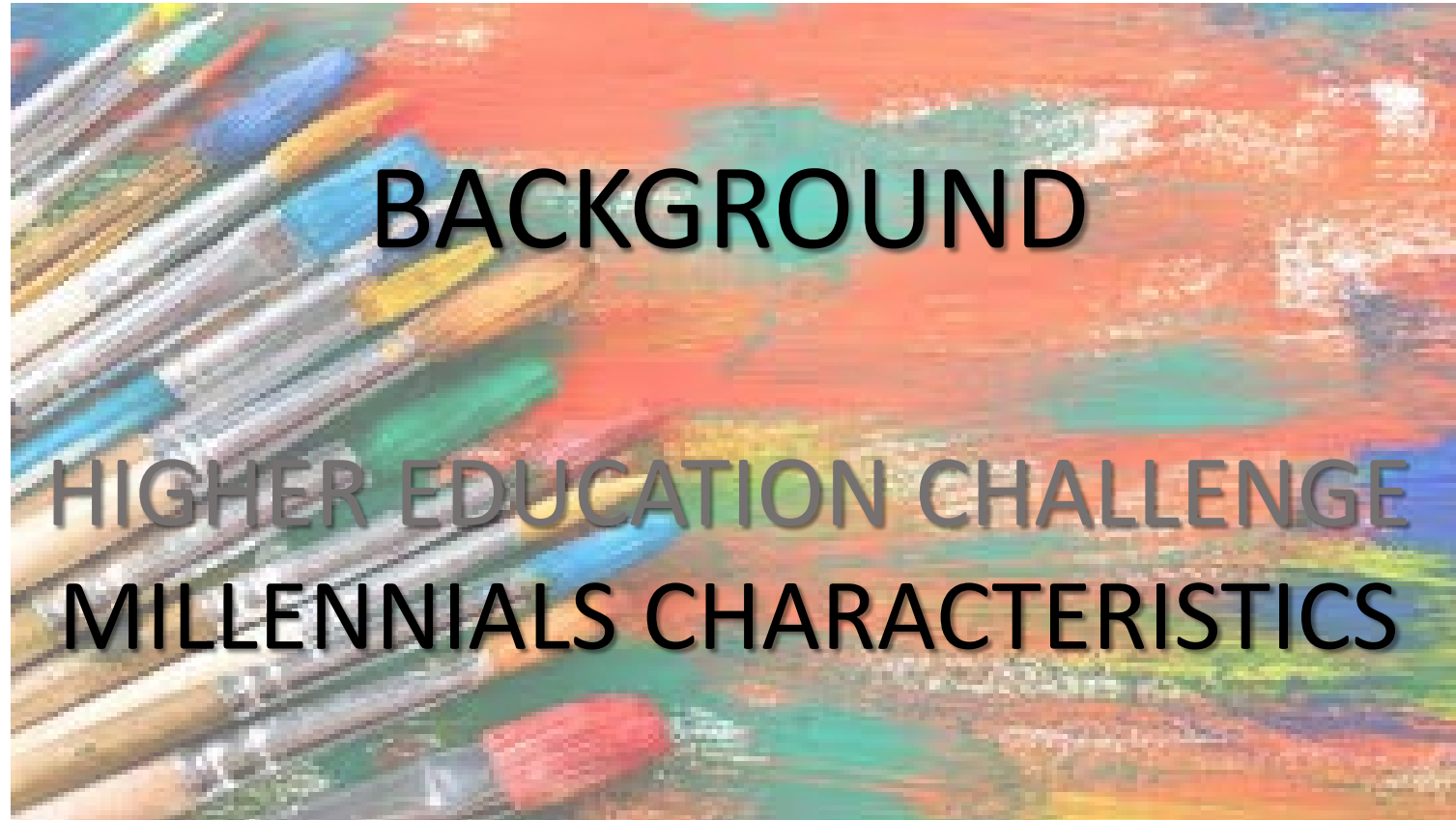
MILLENNIALS CHARACTERISTICS

- Student loan debt
- Time constrained
  - ➢ 1st digital generation
- Anxiety
  - ➢ Job market concerns
  - ➢ Global concerns
    - ➢ climate, war, globalization
- College preparedness

"Give Me A Break" - Joe Biden

Source: Joe Biden doesn't want to hear millennials complain, saying "give me a break"
Summer Meza -
http://www.newsweek.com/joe-biden-says-millennials-dont-have-it-tough-780348

MILLENNIALS CHARACTERISTICS – College Graduates

- High GPAs, work and volunteer experience, travel
  - ➢ Importance of college education increases willingness to pay for it
  - ➢ Debt amplifies concern about getting and keeping a job
- Stiff entry-level job competition
- Aware college graduates had poor job prospects during and after Great Recession

MILLENNIALS CHARACTERISTICS –

How many students have one or more of the following characteristics?

1. Enter College unprepared for engineering courses
2. Lack college-level study skills
3. Underestimate degree of difficulty and fear failure
4. Need better problem-solving skills
5. Do not take enough ownership of learning process
6. Focus too much on grades

MILLENNIALS –
CAMPUS EXPERIENCE

- 40% of freshmen need remedial Math, English[1], both

- Have to learn more technology - software programs (Solidworks) and apps (Blackboard, Canvas, Moodle)

- More opportunities

  ➢ Dual degree programs, Internet/social media, study abroad, extra-curricular, internships, entrepreneurships, volunteerism, business opportunities, start-ups

[1] *Jimenez, Laura. "Remedial Education." Center for American Progress, 28 Sept. 2016, www.americanprogress.org/issues/education-k-12/reports/2016/09/28/144000/remedial-education/.*

MILLENNIALS – CAMPUS EXPERIENCE

- Some underestimate level-of-effort required for academic success (study hours). Possible reasons -
    - K12 grade inflation, insufficient problem-solving (PS) and critical thinking (CT)
    - Student rewards for participation instead of highest achievement
- Some students overestimate value of a degree vs. value of what they learn, hard time searching jobs
    - More emphasis needed on life-long learning

MILLENNIALS – DEGREE USEFULNESS

- Engineering majors most likely to say current job "very closely" related to field of study

- Engineering majors are less likely to say they should have chosen different major to better prepare for job they wanted

Usefulness of Major, by Field of Study

Usefulness of Major, by Field of Study

% of majors in each area who say their current job is ... related to their major in college or graduate school

Legend: ■ Very closely · ■ Somewhat closely · ■ Not very closely · ■ Not at all

Field	Very closely	Somewhat closely	Not very closely	Not at all
Science/Engineering	60	18	6	15
Social Science/Liberal Arts/Education	43	17	12	28
Business	43	29	15	12

Note: Based on those with at least a bachelor's degree who are employed full time or part time (n=606). "Don't know/Refused" responses not shown.

PEW RESEARCH CENTER   Q-40

"The Rising Cost of Not Going to College." *Pew Research Center's Social & Demographic Trends Project*, 11 Feb. 2014, www.pewsocialtrends.org/2014/02/11/the-rising-cost-of-not-going-to-college/.

MILLENNIALS –
MISSED OPPORTUNITIES

Students felt they could have been better prepared

➢ Gained more work experience to position them better for job they want (50%)

➢ Regretted not studying harder (38%)

➢ Should begin their job search earlier (30%)

➢ Should pick a different major (29%)

College Days, Reconsidered

% who say doing each of the following while they were undergraduates would have better prepared them to get the job they wanted

Gaining more work experience	50
Studying harder	38
Looking for work sooner	30
Choosing a different major	29
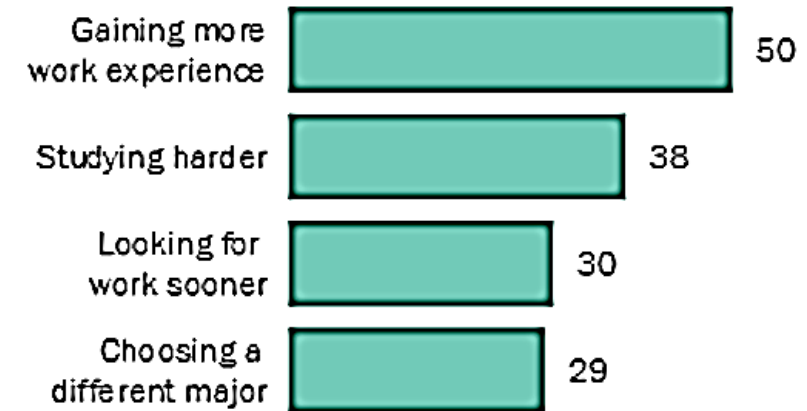
Note: Based on those with at least a bachelor's degree (n=790). Voluntary responses of "Maybe" not included.

PEW RESEARCH CENTER   Q22a-d

"The Rising Cost of Not Going to College." *Pew Research Center's Social & Demographic Trends Project*, 11 Feb. 2014, www.pewsocialtrends.org/2014/02/11/the-rising-cost-of-not-going-to-college/.

MILLENNIALS WORKFORCE – LITERACY GLOBAL COMPETITION

By 2030 Millennials make up 75% of U.S. workforce[1]

- U.S. millennials lag behind most foreign peers in technical skills[2]
- U.S. Millennials score below OECD's[3] average for literacy, numeracy, and problem-solving in technology-rich environments

[1] The U.S. Bureau of Labor Statistics

[2] ETS study of the OECD's PIAAA test results

[3] OECD - Organization for Economic Co-Operation and Development

MILLENNIALS WORKFORCE – LITERACY GLOBAL COMPETITION

Figure 1. Average scores on PIAAC literacy scales for adults age 16–34 (Millennials) and adults age 16–24, by participating country/region: 2012.
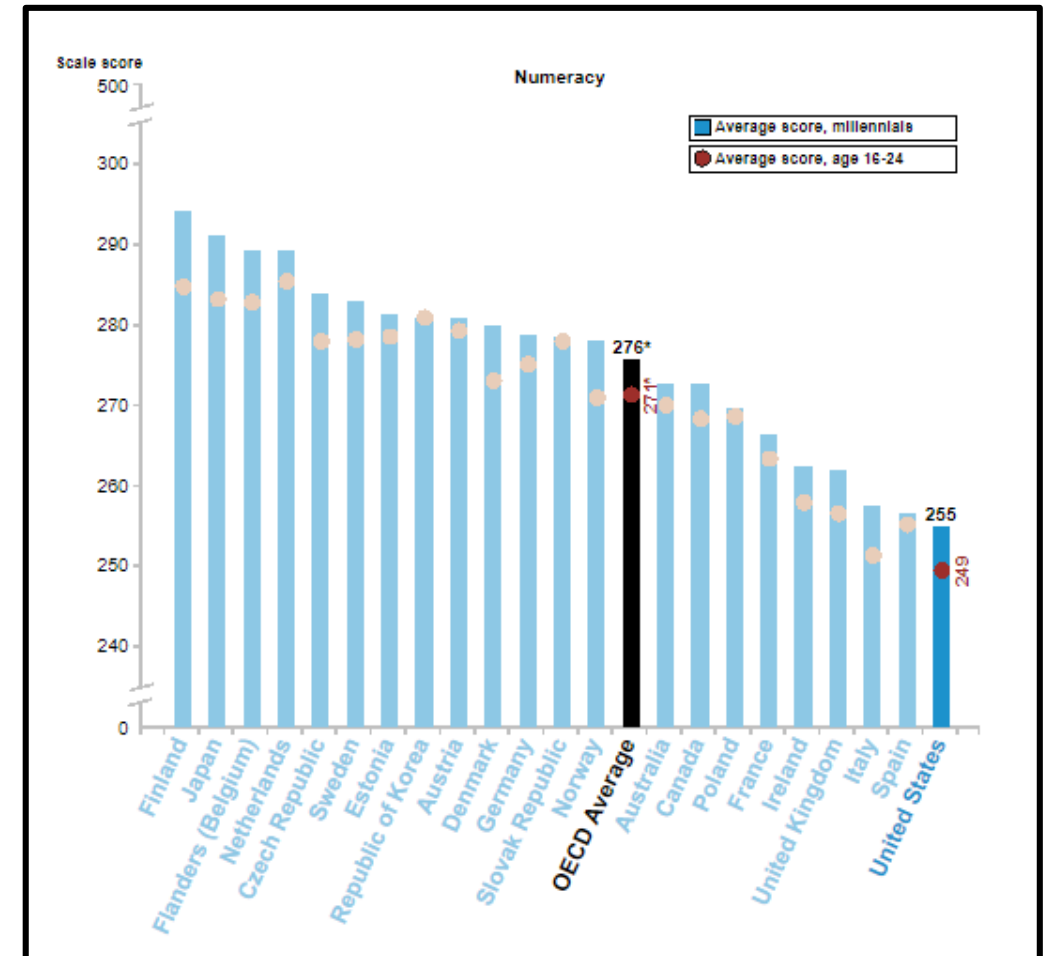
Source: "America's Skills Challenge: Millennials and the Future - Millennials." ETS Home. Web. 21 Dec 2017.
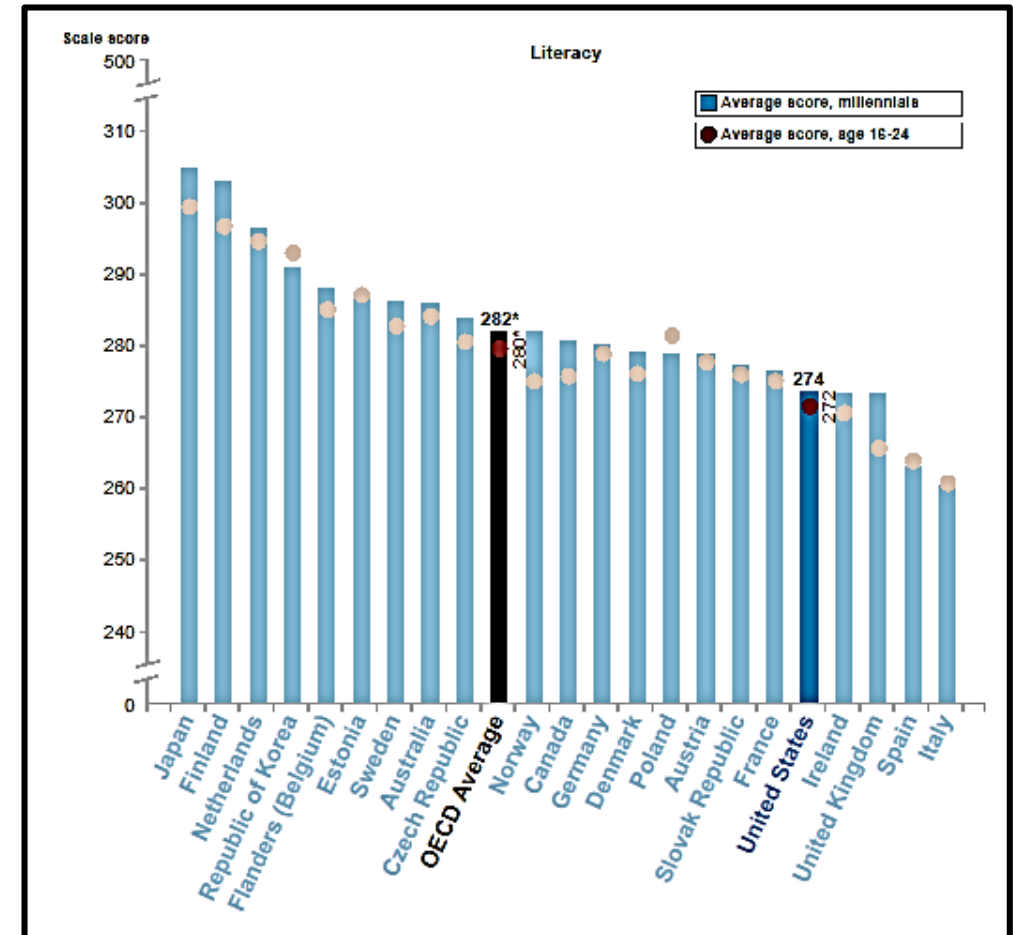
MILLENNIALS WORKFORCE – NUMERACY GLOBAL COMPETITION

Figure 2. Average scores on PIAAC numeracy scales for adults age 16–34 (Millennials) and adults age 16–24, by participating country/region: 2012.

Source:] "America's Skills Challenge: Millennials and the Future - Millennials." ETS Home. Web. 21 Dec 2017.

MILLENNIALS WORKFORCE – PROBLEM-SOLVING GLOBAL COMPETITION

Figure 3. Average scores on PIAAC problem-solving in technology rich environments (PS TRE) scales for adults age 16–34 (Millennials) and adults age 16–24, by participating country/region: 2012.

Source:] "America's Skills Challenge: Millennials and the Future - Millennials." ETS Home. Web. 21 Dec 2017.
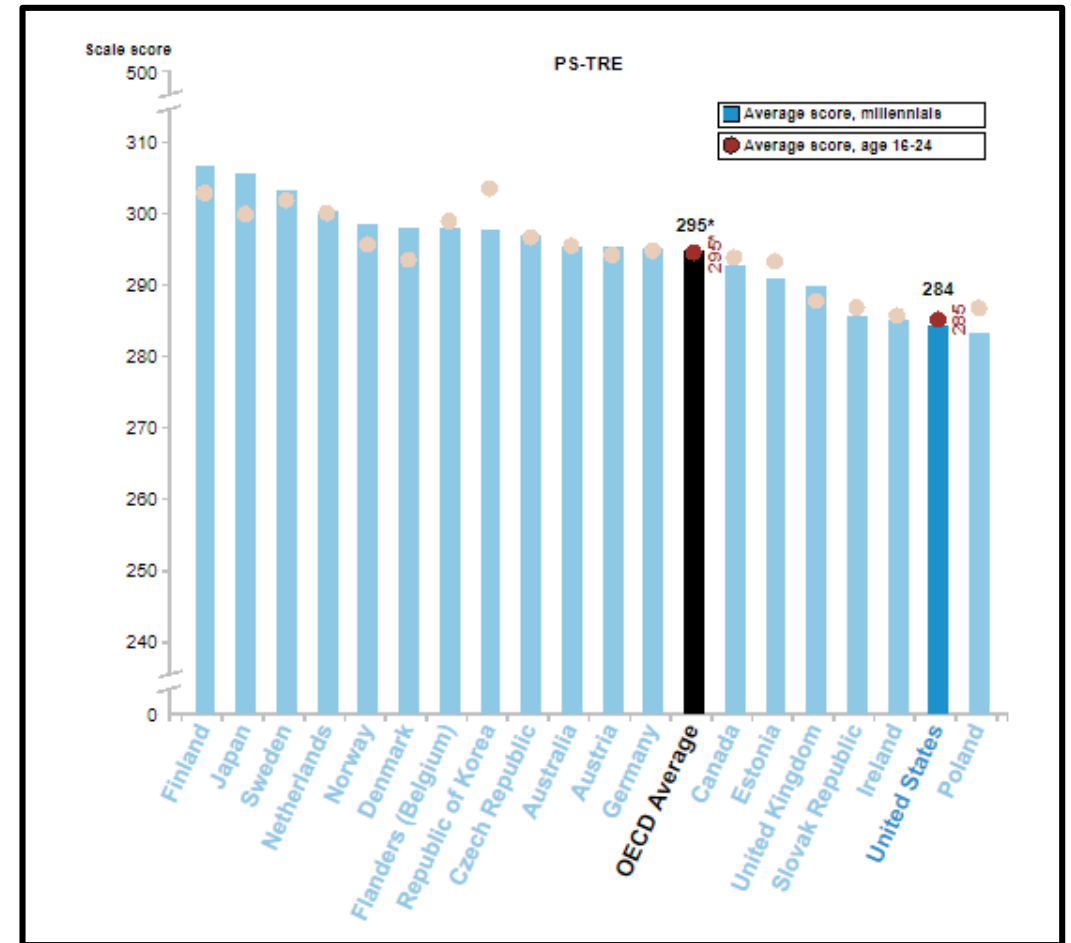
MILLENNIALS WORKFORCE – SOFT SKILLS

PayScale, surveyed 63,924 managers and 14,167 recent graduates in 2016

1. Graduates do not pay attention to detail (56% of managers)
2. Young workers would do well to hone their communication skills (46% of managers)
3. Lack of leadership qualities (44% of managers)

Source: "2016 Workforce-Skills Preparedness Report." PayScale, 2016, www.payscale.com/data-packages/job-skills. Leveling up: How to win in the skills economy

MILLENNIALS WORKFORCE – SOFT SKILLS

PayScale, surveyed 63,924 managers and 14,167 recent graduates in 2016

4. Insufficient interpersonal/teamwork skills (36% of managers)
5. Lacking in public speaking skills (39% of managers)
6. Graduates need to bone up on data analysis — Excel, Tableau, Python, R (36% of managers)

Source: "2016 Workforce-Skills Preparedness Report." PayScale, 2016, www.payscale.com/data-packages/job-skills. Leveling up: How to win in the skills economy

COLLEGE GRADS GET NEARLY ALL JOBS

Of 11.6 million jobs created after Great Recession, 8.4 million went to bachelor's degree recipients

Another 3 million went to associate's degree recipients and students with some college

Employers want workers with at least some college education

"College grads are getting nearly all the jobs - Jun. 30, 2016 ." *CNNMoney - Business, financial and personal finance news.* Web. <http://money.cnn.com/2016/06/30/news/economy/college-grads-jobs/index.html>.

COLLEGE GRADS GET NEARLY ALL JOBS

Rising Cost of Not Going to College
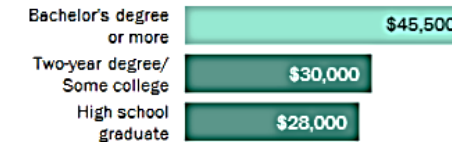
On virtually every measure of economic well-being and career attainment

- **personal earnings**
- **job satisfaction**
- **Full- vs part-time employment**

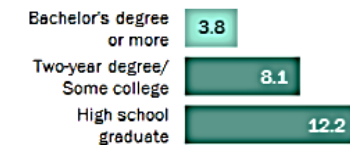**young college graduates outperforming peers with less education**

Disparity among Millennials Ages 25-32 By Education Level in Terms of Annual Earnings ...

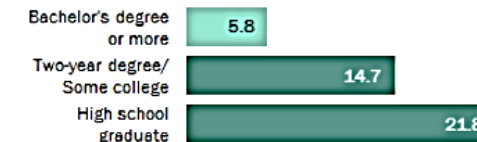Disparity among Millennials Ages 25-32 By Education Level in Terms of Annual Earnings ...
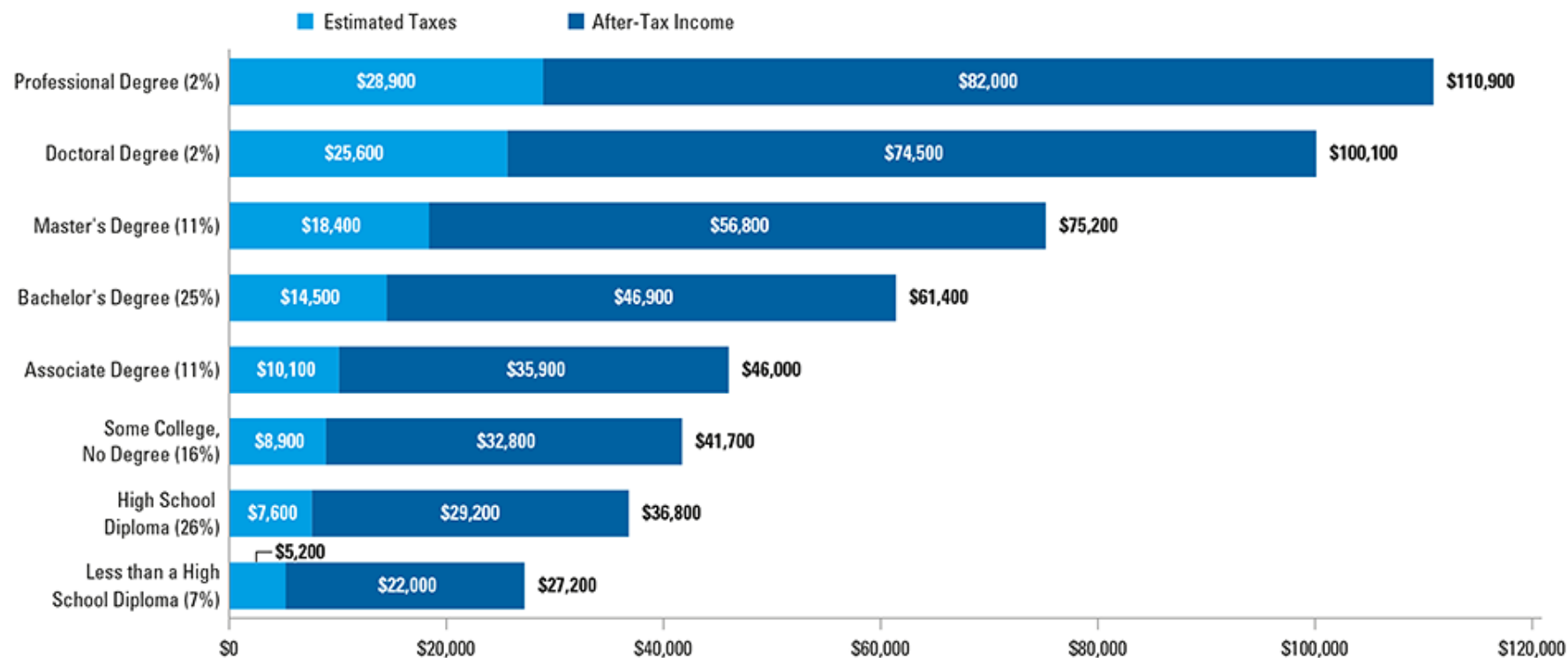(median among full-time workers, in 2012 dollars)

Bachelor's degree or more: $45,500
Two-year degree/Some college: $30,000
High school graduate: $28,000

Unemployment Rate ...
Bachelor's degree or more: 3.8
Two-year degree/Some college: 8.1
High school graduate: 12.2

And Share Living in Poverty ...
Bachelor's degree or more: 5.8
Two-year degree/Some college: 14.7
High school graduate: 21.8

Source: Suh, Michael. "Disparity among Millennials Ages 25-32 By Education Level in Terms of Annual Earnings ..." *Pew Research Center's Social & Demographic Trends Project*, 10 Feb. 2014, www.pewsocialtrends.org/2014/02/11/the-rising-cost-of-not-going-to-college/sdt-higher-education-02-11-2014-0-01/.

Median Earnings and Tax Payments of Full-Time Year-Round Workers Age 25 and Older, by Education Level, 2015

Legend: Estimated Taxes, After-Tax Income

Education Level	Estimated Taxes	After-Tax Income	Total
Professional Degree (2%)	$28,900	$82,000	$110,900
Doctoral Degree (2%)	$25,600	$74,500	$100,100
Master's Degree (11%)	$18,400	$56,800	$75,200
Bachelor's Degree (25%)	$14,500	$46,900	$61,400
Associate Degree (11%)	$10,100	$35,900	$46,000
Some College, No Degree (16%)	$8,900	$32,800	$41,700
High School Diploma (26%)	$7,600	$29,200	$36,800
Less than a High School Diploma (7%)	$5,200	$22,000	$27,200

SOURCE: The College Board, *Education Pays 2016,* Figure 2.1

COLLEGE GRADS GET NEARLY ALL JOBS

Over 99% of job growth in the recovery went to workers with more than a high school education

Workers with a high school diploma or less saw virtually no job market recovery after 2008 Great Recession

Carvenale, Anthony. "Georgetown University Center on Education and the Work Force." *Jobs. Skills. People.* McCourt School of Public Policy, Georgetown University, 30 Jun 2016. Web. 7 Jan 2018. <https://cew.georgetown.edu/cew-reports/americas-divided-recovery/>.

ENGINEERING SALARIES –
Annual Base Pay

- Aerospace Engineer - $130,000
- Petroleum Engineer - $128,000
- Systems Engineer - $84,000

- Mechanical Engineer - $68,000
- Civil Engineer - $66,000
- Biomedical Engineer - $58,000

Employers made STEM graduates top-paid class of 2017 members. Engineering led the way with an average salary of **$66,097.**

HIGHEST SALARY PROFESSIONS
SOURCE: GLASS DOOR

1. Anesthesiologist: $208,000 Median Salary
2. Surgeon: $208,000
3. Obstetrician and Gynecologist: $208,000
4. Oral and Maxillofacial Surgeon: $208,000
5. Orthodontist: $208,000
6. Physician: $196,380
7. Psychiatrist: $194,740
8. Pediatrician: $168,990
9. Dentist: $153,900
10. Prosthodontist: $126,050
11. Nurse Anesthetist: $160,270
12. Petroleum Engineer: $128,230
13. IT Manager: $135,800

14. Marketing Manager: $131,180
15. Podiatrist: $124,830
16. Lawyer: $118,160
17. Financial Manager: $121,750
18. Sales Manager: $117,960
19. Financial Advisor: $90,530
20. Business Operations Manager: $99,310
21. Pharmacist: $122,230
22. Optometrist: $106,140
23. Actuary: $100,610
24. Political Scientist: $114,290
25. Medical and Health Services Manager: $96,540

Gillett, Rachel. "The 25 Highest-Paying Jobs in America in 2017." Business Insider, Business Insider, 8 Mar. 2017, www.businessinsider.com/highest-paying-jobs-in-america-2017-3.

Median Earnings of Early Career and Mid-Career College Graduates Working Full Time, by College Major, 2013–2014
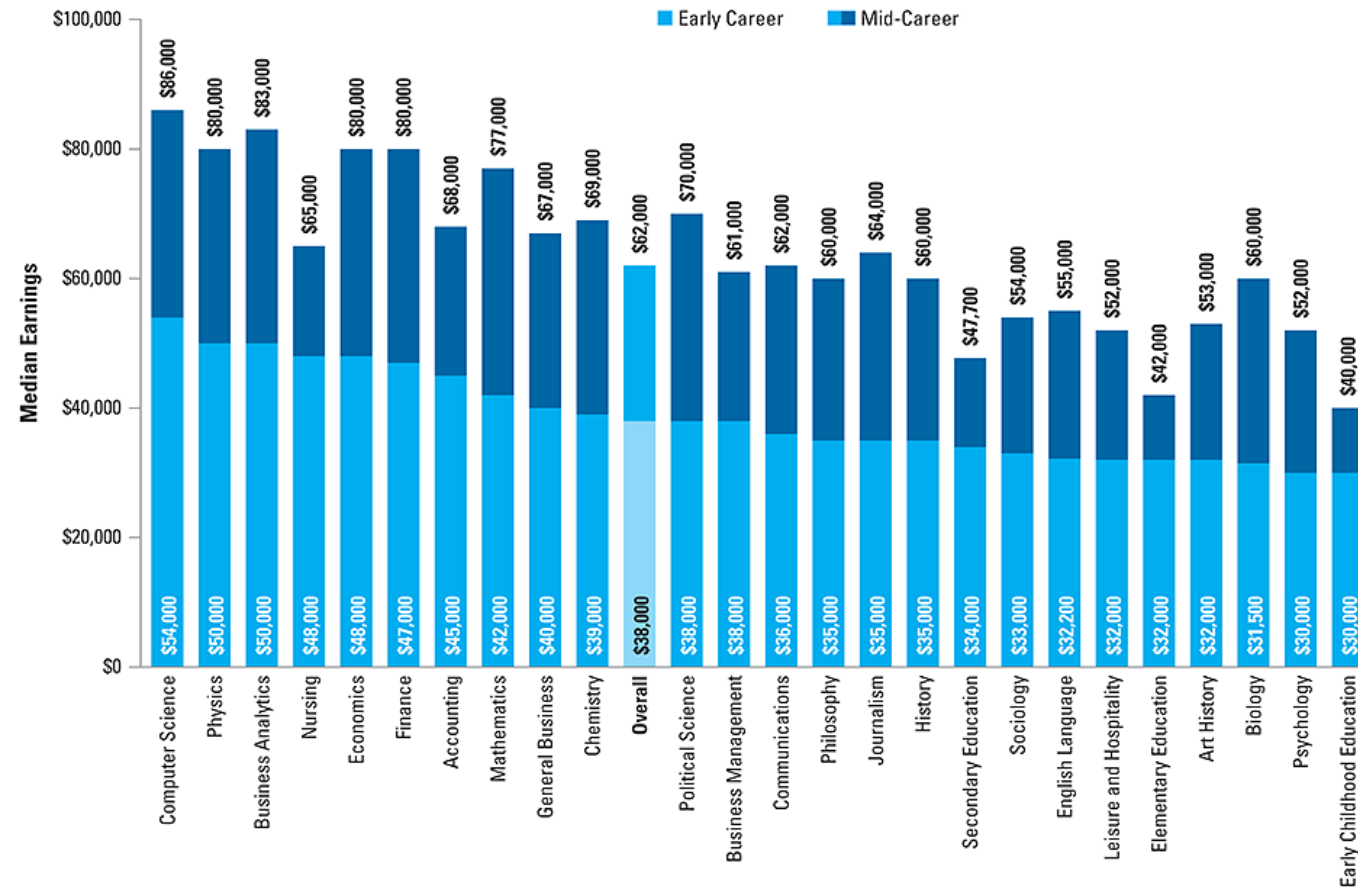
SOURCE: The College Board, *Education Pays 2016,* Figure 2.9

Estimated Cumulative Full-Time Earnings (in 2014 Dollars) Net of Forgone Earnings and Payment for Tuition and Fees and Books and Supplies, by Education Level
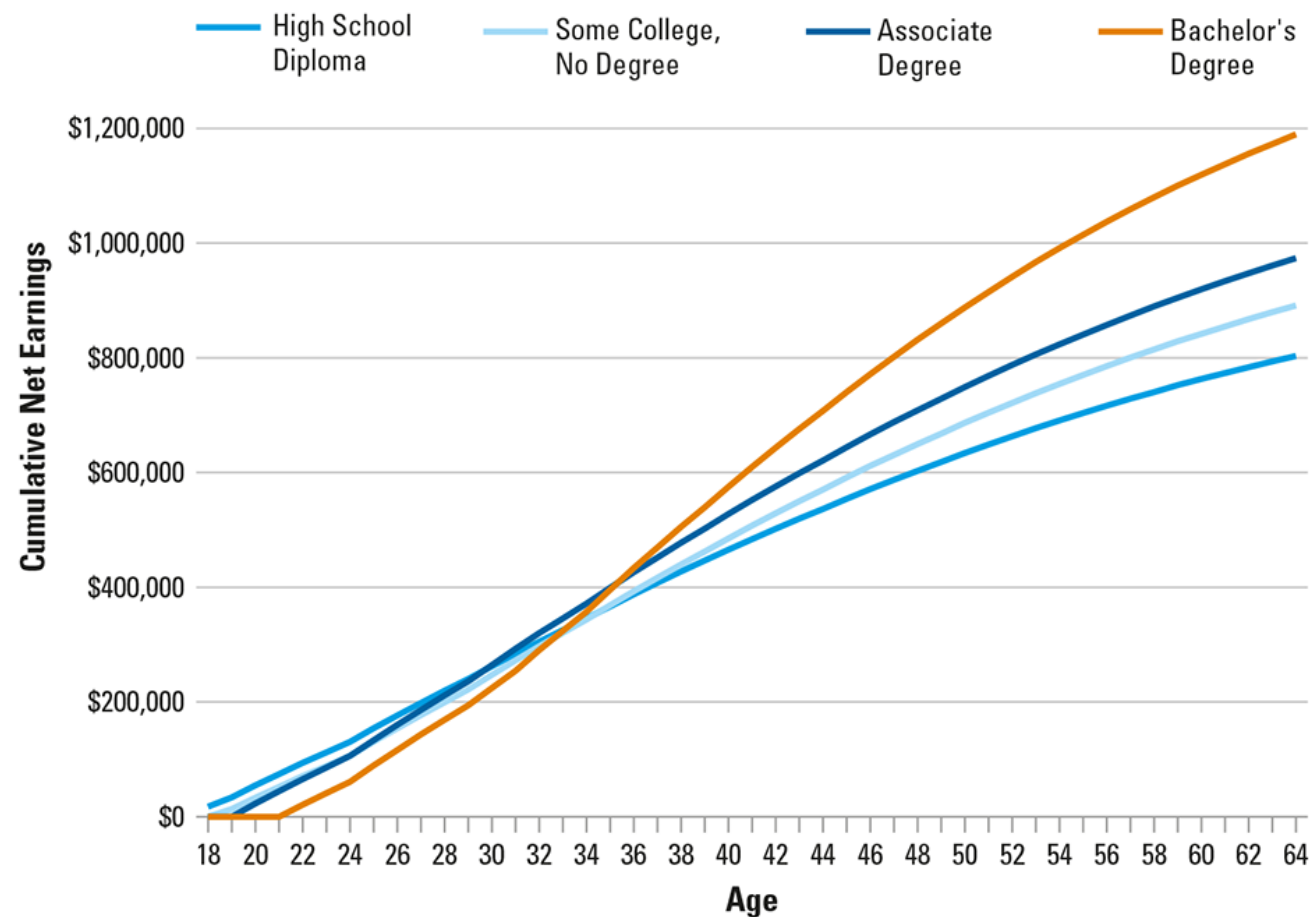
SOURCE: The College Board, *Education Pays 2016,* Figure 2.2A
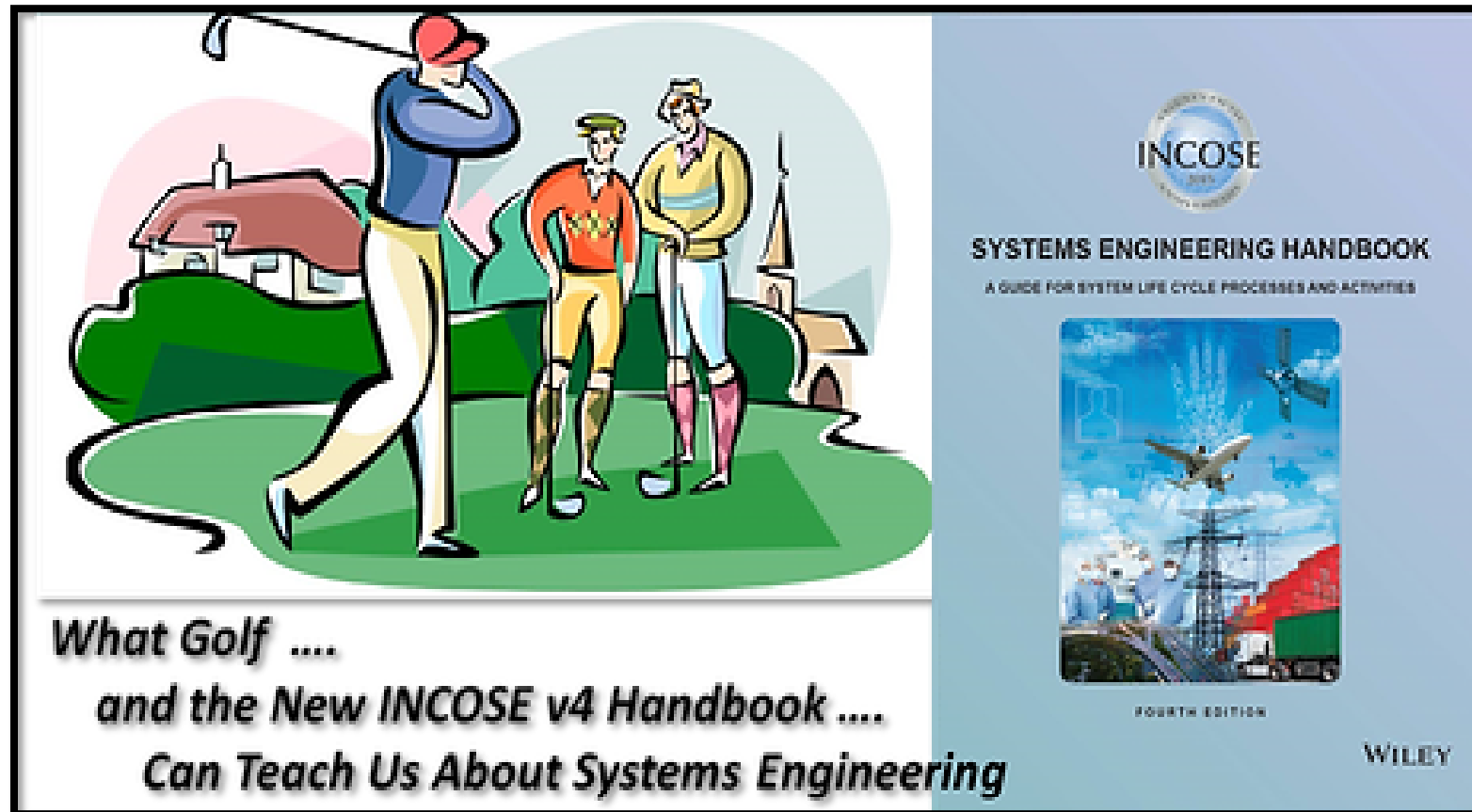
TEACHING SE TO NON-SE STUDENTS

IMAGE: INCOSE

TEACHING SE TO NON-SE MAJORS –

- ME, EE, AE, CE, BME
  - ➢ SE electives only
  - ➢ Curricula full, courses challenging
  - ➢ ESL and SE terminology - barriers
- SE at work – difficult to teach on campus
  - ➢ IPTs, Agile, flat vs. hierarchical organizations
  - ➢ Large-scale projects require SE
  - ➢ Complexity – tech, cost, schedule, logistical, etc.

PHOTO: NSU

TEACHING SE TO NON-SE MAJORS –

- Methods, processes, codes, standards, theory (software), technology – SE can be learning roadmap
  - **SE is how to design, manage complex systems over life cycles**
    - **Examples - requirements, determining design drivers**
  - **Steep learning curves, learn faster than older workers**
  - **Inexperienced, older workers leverage prior knowledge better**
- Interdisciplinary course development needed
- More experiential learning - facilitated, active learning
  - **Foundation for understand/apply what is learned**
  - **Sever/Industry student learning partnerships**
- SE span curriculum, integral to teaching IL/PS/CT

TEACHING SE TO NON-SE MAJORS - OBSTACLES

- Faculty for course integration, modification
- More collaboration between academic depts.
- Articulate SE value proposition
  - ➢ students, parents, faculty, administrators
- Integrated software tools needed for LMS
  - ➢ Blackboard, Canvas, Moodle, etc.
  - ➢ LMS can hinder sharing information, changes

TEACHING SE TO NON-SE MAJORS – INTERDISCIPLINARY PROGRAMS (IP)

- Requires more IP, project-based courses
- Faculty support for IP from administrators
  - Logistics, workload, coordination
- IP need full integration into curriculum
  - past courses largely stood alone
  - Individual faculty cannot be required to sustain IP
- IL/PS/CT - projects with SE content
  - Engineering roles, cost accounting, scheduling, etc.

TEACHING SE TO NON-SE MAJORS

Therefore, education needs to shift "*from education as a content transfer to learning as a continuous process* where the focused outcome is the ability to learn and adapt with agency as opposed to the transactional action of acquiring a set skill," said McGowan.

"Instructors/teachers move from guiding and accessing that transfer process to providing social and emotional support to the individual as they *move into the role of driving their own continuous learning*."

Friedman, T. (2018). *Opinion | While You Were Sleeping*. [online] Nytimes.com. Available at: https://www.nytimes.com/2018/01/16/opinion/while-you-were-sleeping.html [Accessed 18 Jan. 2018].

CONLUSION

1. Quality education requires *teaching excellence*

   Innovation requires life-long *learning excellence*

   ➢ Curiosity, ideation, creativity, risk-taking, setting ambitious goals, ingenuity

   ➢ *Difficult to teach, can be encouraged, acquired*

2. SE is an excellent growth mindset framework, IL/PS/CT

At stake - new intellectual wealth Millennials will build on their foundation of inherited intellectual wealth

For more information, visit:

trends.collegeboard.org

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