AN INDUSTRY PERSPECTIVE ON STEM EDUCATION FOR THE FUTURE: ISSIP-NSF WORKSHOP

Dec 10, 2019
Lucas Business Complex,
San Jose State University
Santa Clara, CA

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Event Website: http://www.issip.org/events-news/issip-nsf-workshop-dec-10-2019/

Sponsors:

National Science Foundation
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Table of Content

Report Summary

Automation, powered by advances in machine learning and data science, is super-charging innovation and disrupting industries and jobs. Work in America looks very different from a couple of decades ago, and it will look even more different going into the future decades. As more and more repeatable tasks are relegated to machines, some jobs will disappear, and new ones will appear. For new jobs to offset the losses, particularly in the fields of Science, Technology, Engineering, and Mathematics (STEM), America requires an adaptable workforce with a new set of skills, according to a recent report from McKinsey Global Institute (2019).

To gain an industry perspective on how STEM undergraduate educational institutions might best meet these expected demands for new skills, the International Society of Service Innovation Professionals (ISSIP) was awarded by the National Science Foundation (NSF) to undertake a project to seek such a perspective in order to inform higher education leaders on workforce re-skilling and educational trends that industry views as important and necessary for a thriving workforce - today and in the future.

The ISSIP approach to the project consisted of conducting a workshop, augmented by stakeholder feedback. A panel of experts ("Expert Panel") was assembled, and initial input was obtained from stakeholders through Surveys and Dialogues. A one-day Workshop was held with industry leaders and members of academia having strong industry exposure, followed by additional surveys with a wider set of stakeholders, and finally synthesizing all the findings into this report. Expert Panel members were selected based on two criteria: 1) Each member had to be involved or have visibility into current corporate college hiring process; and 2) The panel had to have diverse representation across a variety of industry verticals including Information Technology, Telecommunication, Media and Entertainment, Internet, Professional Services, Financial Service, Healthcare, Transportation, Infrastructure, Insurance, Education, Government, and more.

It is important to note that this research was conducted under the assumptions of the "old normal" before the COVID-19 crisis hit the US, e.g., low unemployment, STEM talent scarcity, relatively low demand for remote work and learning. While it is important to study the long-term impact of the crisis to our findings, that is outside the scope of the current project and therefore this report. The study team plans to propose additional research on the impacts of the COVID-19 crisis.

The following is a summary of the findings from the Stakeholder Feedback and the Workshop.

Stakeholder Feedback
One significant goal of this project was to collect industry input for the Workshop through a Survey.

An online Survey, based on issues defined defined by NSF of importance for the Future of Undergraduate STEM Education, was tested with a small sample from the Expert Panel, fine-tuned with feedback, then implemented in two phases with full Expert Panel and the workshop participants. Stakeholder Dialogues were conducted with a subset of survey respondents. See

Section 4, “Stakeholder Feedback,” for details.

Key Takeaways from the full set of Surveys are summarized below in Table 1.

An Industry Perspective on STEM Education for the Future
Rapid technology advances are changing the nature of jobs, resulting in jobs that are driving demand for new skills.
Universities are lagging behind in teaching undergraduates some of the skills needed for industry entry-level jobs.
High demand skills span a broad range that can be categorized as “Specialized Skill” (technical in nature), and “Foundational Skills” (general in nature.) Industry is dependent on both categories of skills.
Undergraduate hires come to work well-prepared with Specialized Skills but not well-prepared with Foundational Skills.
Industry demand is increasing for candidates that have practical experience through internships and co-ops.
US universities are not producing enough American STEM graduates to satisfy industry needs, and therefore industry has turned to candidates with H1B visas.
Badging and verifiable skills are considered by industry as augmenting, not replacing, 4-year degree programs.
“Life-long learning” and “pervasive learning” are viewed as very important.
A basic level of computing skills is required, even for non-technical jobs, in STEM work environments.

Table 1 – Survey Takeaways, An Industry Perspective On STEM Education For The Future

Workshop
A second significant component of this project was a one-day Workshop with industry executives.

The One-Day Workshop[1], “An Industry Perspective on STEM Education for the Future,” held on Dec 10, 2019, brought together 36 participants and included one guest. The participants included experts from industry, academia, and government foundations, recruited to reflect diverse perspectives on STEM education and STEM jobs for the future. The agenda consisted of two speaker presentation sessions, three Q&A panels, and one breakout session. See Appendix A for more details.

Workshop Panel Summaries:
In the **first panel,** speakers representing high tech, media, telecom, financial and professional services acknowledged that STEM job opportunities today, and for the foreseeable future, center on many areas of STEM – including artificial intelligence, cybersecurity, cloud computing, data science, IoT (Internet-of-Things), open-source, and blockchain. Additionally, jobs in emerging fields such as quantum computing, biomedical, control systems, robotics, telerobotics, augmented reality, and virtual reality are already present today. The “Specialized Skills” (Figure 1) required for these current and emerging jobs are constantly changing as

[1] Please see the Workshop website: http://www.issip.org/events-news/issip-nsf-workshop-dec-10-2019/

technologies continue to advance, and therefore lend themselves better to micro-learning modes of education than to established curricula, in order to facilitate rapid response to evolution of reskilling needs.

Higher education, according to the first panel, needs to re-focus the 4-year STEM degree programs to provide the broad “Foundational Skills” (Figure 1) that are essential over the lifespan of careers and actually prepare learners for life-long micro-learning. The panel also made a distinction between STEM jobs and STEM degrees. While it is anticipated that the majority of good paying entry-level jobs will be in STEM, according to the panel, not everyone who is taken into that job market need be a graduate of a STEM academic degree program. That being the case, higher education leaders are advised to think about how to prepare both STEM and Non-STEM students for the new STEM jobs.

Accordingly, the panelists stated that it would be a mistake to focus on STEM education at the exclusion of liberal arts. The panelists concurred that liberal arts graduates with a baseline level of “digital skills” will be in greater demand in the coming years, particularly as AI becomes more pervasive in the workplace. Also, many of the Foundational Skills such as abstract thinking, conceptual problem solving, human-centered design, and creativity are fostered by a liberal arts education. Finally, the panel characterized STEM graduates as coming to work for their first post-graduation job fairly well-prepared with technical Specialized Skills, but often lacking the Foundational Skills necessary to perform well in those jobs and beyond.

In the **second panel,** speakers representing healthcare, infrastructure, state government, and insurance acknowledged that their sectors are going through major transformations resulting in increased demand for STEM graduates. They indicated that, in their observation, the STEM graduates enter the workforce fairly well-prepared with technical skills, but they often lack the Foundational Skills that are necessary to apply those skills effectively to solve problems in the business context. The panelists emphasized the opportunity for higher education to partner with industry to foster experiential job-relevant learning through structured apprenticeship and internship programs that are integrated into university curricula.

The speakers in the **third panel** represented views from several innovative education organizations that are leveraging successful partnerships to rapidly fill the skills gap between education and employment. This panel also pointed out how higher education can better partner with industry to ensure the relevance of academic content to industry and to foster job-relevant experiential learning through well-structured apprenticeship and internship programs. Pioneering industry-education collaboration models come in different forms. Some universities and community colleges are partnering with novel learning organizations and local businesses to bring experiential and career-enhancing learning to students. Other universities are partnering with educational startups to provide career pathways to STEM jobs for underserved student populations. Also, innovative service organizations are offering the content of their high-demand industry certifications to universities for integration into academic curricula in order to develop rapid micro-learning capabilities.

Workshop Breakout sessions:
There is a lot to be proud of with regard to US higher education. It is considered “the best in the world” (The Economist, 2018) as measured by metrics such as a percentage of the world's Nobel prize-winners, the output of articles on science and engineering, frequency of cited articles, and accessibility (proportion of the population going on to higher education). While US

higher education institutions are tremendous assets to the nation, they also face challenges in order to fulfill their roles in preparing the next generation of the US workforce for 21st century jobs. To explore this in more depth, the workshop participants were asked to form four breakout groups. Each group was asked to perform its own SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) of today's US higher education systems and institutions. After 1 hour, the groups reported out to each other. A combined view across the four groups for each of the SWOT components is presented below.

Strengths - The strengths of the US higher education lie in the high-quality standard of higher education and in the diversity and flexibility of degree programs for learning and research. This opinion extends to both STEM and Liberal Arts, as well as those higher education environments that allow learners to build social and cultural networks beyond the classroom walls.

Weaknesses - The weaknesses include the high cost of education that is making access to higher education (a characteristic that historically has been a strength) increasing more challenging for many Americans. The weaknesses also include an imbalance of American vs. international graduates, as well as a disconnect from industry and from skills requirements for the workforce. Additionally, an under-emphasis on liberal arts and humanities education in STEM curricula is resulting in lack of Foundational Skills preparedness in new college hires. Finally, academic institutions are typically seen as risk-averse cultures with siloed curriculum structures resulting in slow response to industry changes.

Opportunities - The opportunities for higher education lie in building more bridges to industry, including internships, co-ops and apprenticeships. In addition, forming partnerships with other learning organizations to pave the way for offering more industry focused project-based/problem-based and life-long learning opportunities. Furthermore, higher education leaders are advised to explore opportunities for providing lifelong learning beyond the degree, so current students can become "customers" for life, not just for 4-years.

Threats - The democratization of information raises the bar for the traditional academics, as knowledge from top scholars is available free or at costs far lower than many higher education degree programs. In addition, the perceived lack of relevance in traditional higher education disciplines and structures has contributed to an eroded confidence in the 4-year STEM degree as the pathway to high paying jobs and has widened the perceived gap between expectations for 4-year STEM degrees and confidence in their ability to fulfill those demands.

The key takeaways from the Workshop:
Panel speakers and participants identified a number of important skills as required for new jobs of today and tomorrow. These skills (Figure 1) were viewed as belonging to two major categories: 1) Specialized Skills designating those technical and scientific skills for which requirements keep changing as technologies advance, and 2) Foundational Skills which include those skills that are long-lasting and transferable across technologies, jobs, companies, and even industries. While acquiring Specialized Skills is a reasonable strategy for learners to start preparing for the STEM jobs of the future, according to the workshop participants, they considered the strategy far from sufficient. To be sufficiently prepared, industry representatives in this panel agreed that STEM graduates must come to work also prepared with the Foundational Skills that will enable them to adapt quickly to the constantly changing environment of work.

Based on input from the Workshop and Survey, two types of Foundational Skills were identified: a) “Work Practice Skills;” and b) “Soft Skills”. In this view, “Work Practice Skills” are those skills mostly pertinent to work processes, such as human-centered design, agile, service thinking, and interdisciplinary skills, while “Soft Skills” are those skills such as interpersonal & communications skills, risk-taking, and collaboration. In addition to both types of skills, according to the industry participants in this study, New Mindsets are required to constantly reskill and upskill across these skills dimensions. These mindsets include the “Growth Mindset,” “Probabilistic Thinking,” “Design Thinking,” and “Service & Systems Thinking.”

Finally, a dire need for greater representation of women and members of minority groups in reskilling and upskilling efforts was repeatedly mentioned by the Workshop panelists (and in the survey responses); it is also evident in industry trends (Simonite, 2018).

Recommendations:
Considering the great strengths of the US higher education enterprise and the industry perspectives gathered from the Workshop and Stakeholder Feedback, the following summarizes the project’s recommendations to higher education leaders:

<u>Incentivize, Strengthen, and Create</u>

1. Incentivize
    - Empower and reward faculty for cross-disciplinary and higher education/industry engagements.
    - Incentivize organizations and individuals to build bridges between higher education and industry in order to regularly exchange critical information on job requirements, needed skills, and educational opportunities.
    - Catalyze the development of innovate programs to offer students job-relevant experiential learning opportunities.
2. Strengthen
    - Leverage strengths inherent in the diversity and flexibility of STEM degree programs.
    - Emphasize the importance of liberal arts/humanities and their integration into STEM coursework and experiential learning and promote the importance of digital literacy for liberal arts majors.
    - Expand STEM curricula to enhance alignment of content with industry-relevant applications.
    - Increase student opportunities for applied learning through structured apprenticeship programs, Co-Ops, and paid internships.
    - Foster lifelong learning.
3. Create
    - Integrate Foundational Skills into student learning opportunities.
    - Develop and offer micro-learning programs for Specialized Skills development.
    - Offer project-based learning opportunities throughout the undergraduate program (not limited to “Senior Projects” only).
    - Involve industry representatives in regular, periodic curriculum communications, exchanges and reviews (e.g., industry advisory boards).

Further consolidating the critical skills and mindsets identified in both the Workshop and Stakeholder Feedback, Figure 1 summarizes an industry perspective on high-demand skills for the STEM jobs of the future.[2]

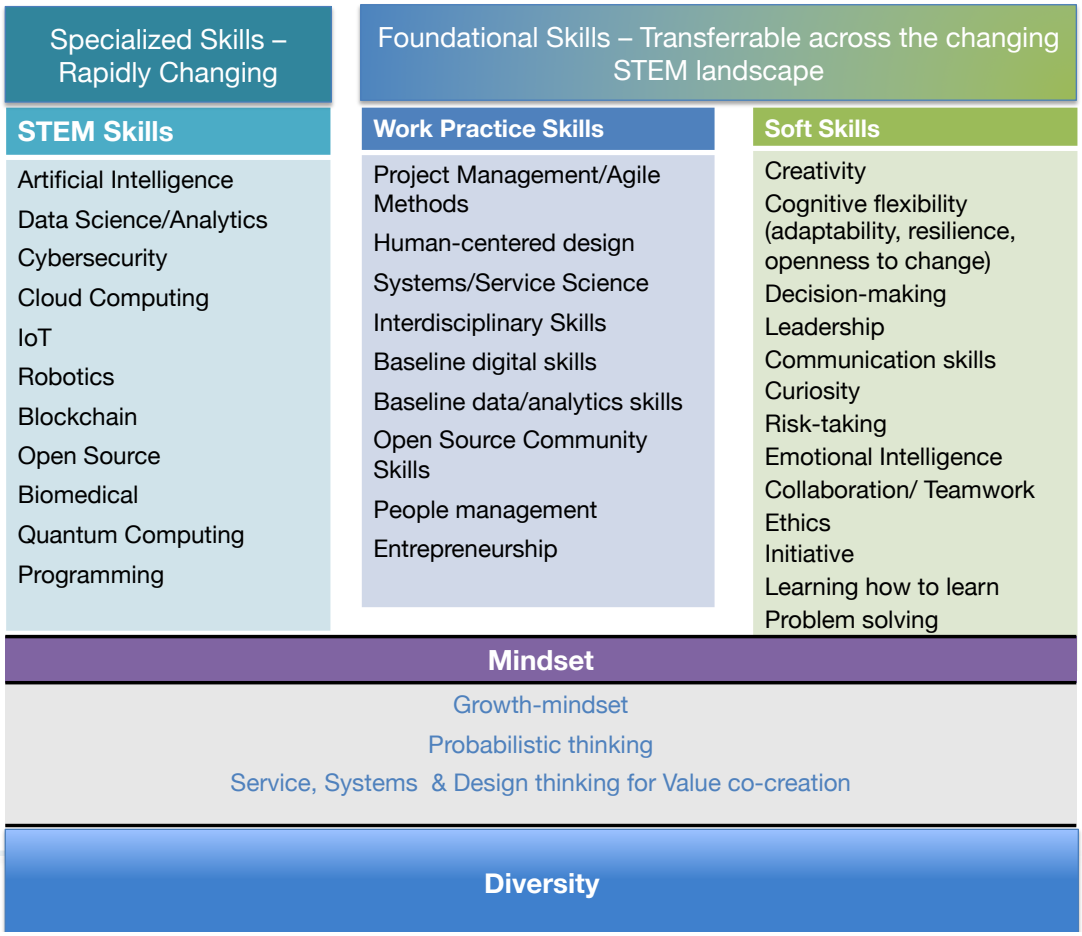


Figure 1 – An Industry Perspective On Skills Requirements For The Future

By providing this industry perspective to further align higher education and entry-level employment, this report presents advice from industry leaders to inform US higher education leaders about the skills that industry views as essential for the new high-paying jobs of today and tomorrow in order to fuel a thriving American industrial sector.

[2] The dimensions shown in Figure 1 are similar to those of the "T-shape" paradigm (Moghaddam, et al., 2018), in which the "I" of the "T" includes Specialized Skills and the bar of the "T" Foundational Skills.

Full Report

1 Background

Innovation drives economic growth; and talent in science, technology, engineering, and math (STEM) fields is critical to the nation's innovation leadership. Innovation capacity is especially critical, since we are at a juncture in our nation when jobs are rapidly changing. Technological advances are driving disruptive changes to work behaviors and business models, and these changes will have a profound impact on the nature of work, skills, and the composition of the workforce. In many industries the most in-demand occupations, specialties, and skills of today did not exist ten or even five years ago, and the pace of change is set to further accelerate. This rapid pace of change will have a tremendous impact on how the workforce of the future acquires and applies new skills.

To gain an industry perspective on how undergraduate educational institutions might best meet these expected new demands, the International Society of Service Innovation Professionals (ISSIP) conducted a project for the National Science Foundation's program, "Accelerating Discovery: Educating the Future STEM Workforce." The purpose of the project was to obtain an understanding of industry leaders' views on the requirements and results of US undergraduate STEM educational programs in support of workforce readiness for jobs in a thriving 21st-century industry sector. The workshop approach called for obtaining perspectives from an invited panel of experts in a one-day workshop, as well as designing and conducting a brief survey focusing on the issue of improving STEM education at the undergraduate level of higher education. The project began in June 5, 2019.

The project examined future work environments and the types of expertise needed, together with preferred formats for skills acquisition and work rules. It also examined industry-driven certification systems (including standards, benchmarks, and badging) and industry practices for skills validation. Furthermore, the project queried talent pipelines used by industry today and trends for the future (including internships, apprenticeships, onboarding, continuing professional development and life-long learning).

In addition, the project explored the challenges faced today by recent 4-year STEM graduates entering the workforce, with regards to meeting current industry demands as well as successfully navigating future career pathways, and whether such persons are likely to face competency issues, shortfalls or omission in their skills. In particular, the project requested feedback on how students are being prepared with STEM Specialized Skills as well as Foundational Skills (general skills regardless of discipline), so that the graduates are productive when entering the workforce. Additionally, this project sought industry views on the merits of certification and badging as alternatives or augmentation to academic courses.

A final goal of the project was to examine whether a gap will exist between current undergraduate STEM educational program content and future job-readiness, and, if so, how this gap might be closed by modifying STEM educational content and processes. The overall goal of this discovery process was to help to assure that American higher education in the future will be able to supply talent for a thriving US workforce. By providing an industry

perspective on a possible skills mismatch between higher education and employment, this research sought to provide input to help higher education leaders develop programs that will increase America's innovation capacity for the high-paying jobs of today and tomorrow.

This Full Report describes in detail the outcomes and findings of this project.

2 Approach

ISSIP carried out this project in 2 phases. The first phase, "Phase 1," included the period from the start of the project (June 5, 2019) to and including the date of the Workshop, Dec 10, 2019. The second phase, "Phase 2," began immediately after the Workshop and ended with the submission of this Report to NSF. The approach is outlined below:

Phase 1

1. Input the initial Survey (the version submitted to NSF in the project proposal) into the Qualtrics survey platform.
2. Empanel experts with responsibly for, or with visibility into, corporate university/college recruiting, to assemble a panel of experts, the "Expert Panel" (with minimum requirement of 25 industry-representative members across diverse industry verticals).
3. Seek feedback from a subset of Expert Panel members to pilot the Survey.
4. Modify the initial Survey based on feedback gathered in #3, to construct "Survey Phase 1."
5. Distribute "Survey Phase 1" to the Expert Panel for Phase I data gathering prior to the Workshop.
6. Conduct Dialogues with a subset of the Expert Panel to identify crucial Workshop topics.
7. Summarize results of "Survey Phase 1" for presentation and discussion with the workshop participants.
8. Conduct a 1-day interactive Workshop on Dec 10, 2019, to obtain industry input on the Stakeholder Feedback from Phase 1 and to obtain position statements on the Workshop topics.

Phase 2

9. Conduct "Survey Phase 2" after the Workshop to increase the number of stakeholders responding to the Survey, with the goal of N=100. This goal was later revised to 75 with agreement with NSF, due to implications of COVID-19.
10. Analyze the collected results from the Workshop and Stakeholder Feedback.
11. Develop this Final Report and submit the report to NSF.
12. Submit a proposal to Business Expert Press for publication of a book version of this report. See previously ISSIP-BEP published books: http://bit.ly/2xSIxE1.

3 Expert Panel

The Expert Panel was assembled by developing a list of 90 industry leaders from the ISSIP membership roster who were known to have responsibility or visibility into the corporate college hiring process, either as HR leaders, as direct hiring managers, or as business strategists. The list represented experts from diverse industry sectors including ICT, media &

entertainment, internet services, professional services, government, automotive, aviation, healthcare, transportation, financials, manufacturing, agriculture and financials. The size of the Expert Panel was set to a minimum of 25 and a maximum of 35 members (based on the requirement to keep the size of the Workshop between 30-40 participants). To prevent oversubscription to the Workshop, 50 from the list of 90 who had been recently engaged in the ISSIP future-of-work initiatives were invited to join the Expert Panel. Thirty-five of these 50 experts accepted. For a list of Expert Panel members, please see Appendix B.

All 35 Expert Panel members were invited to participate in the Workshop. Of the 35, 24 accepted to participate. Of the 24 who accepted to participate, 16 agreed to moderate or speak on one of the workshop panels.

No compensation or incentives were offered or given to members of the Expert Panel.

4 Stakeholder Feedback

One component of this project, in addition to the Workshop, was to collect industry perspectives through Surveys. To augment Stakeholder Feedback from Surveys, teleconference Dialogues were also held with selected survey respondents.

4.1 Survey Methodology

Consistent with the two project phases, the Survey was also conducted in 2 phases as described in section 2.

To develop the Survey Phase 1, the survey, as proposed to NSF in the project proposal, was put online and sent to eight members of the Expert Panel to solicit feedback on the content, and to ensure the Survey covered critical topics. After incorporating the feedback collected from this subset of the Expert Panel, the “Survey Phase I” was established.

After developing Survey Phase 1, the Survey and the protocol to administer it were sent for an IRB review that was conducted by the Institutional Review Board, Division of Research and Innovation of San Jose State University (IRB-SJSU). The Board determined that the activities described in the project protocol did not constitute research involving human subjects and did not require IRB review under Section 1.2 of F17-1 SJSU Policy for the Protection of Human Subjects. The Board further stated that human subject considerations are involved when the research entails interaction or intervention with living individuals that solicits personal information or the collection of individually identifiable private information. Since the survey did not involve personal information, it did not require an IRB review. Appendix C presents the IRB’s waiver letter dated Sept 16, 2019.

Survey Phase 1 was conducted from Nov 1 to Nov 30, 2019, leading to the Dec 10 workshop, by collecting responses from the members of the Expert Panel. Survey Phase 1 was sent to all the 35 members of the Expert Panel. By Nov 30th, 23 members had responded. Results of Survey Phase 1 were summarized for review with the participants at the Workshop, and to identify crucial topics and candidate speakers for the Workshop. Dr. Stephen Kwan conducted the analysis of the results and presented a summary of the Survey Phase 1 results at the Workshop.

Survey Phase 2 was conducted after the Workshop, from Feb 1- May 1, 2020, to increase stakeholder responses. Based on the feedback obtained during the Workshop, the Survey Phase 2 was slightly modified to improve language clarity for one the questions - without substantive change to the question or the survey. Survey Phase 2 was sent to those industry members of ISSIP known to have responsibility for or visibility into their company's college recruiting process. Through email, 350 ISSIP members, representatives of HR or other corporate functions with director responsibility or visibility into college hiring, were requested to fill out Survey Phase 2. Two email reminders to non-respondents followed the initial email.

Both Survey Phase 1 and 2 were relatively short, a total of 10 questions, which took, on average, 15~20 min to complete.

By May 1, 2020, when Survey Phase 2 was closed, 75 responses had been obtained across diverse industry sectors including ICT, telecommunication, media and entertainment, internet, professional services, financial service, healthcare, transportation, infrastructure, insurance, education, and government. Due to conditions presented by COVID-19, further data collection was curtailed.

4.2 Dialogue Process

All members of the Expert Panel were invited to a post-survey Dialogue; twenty out of thirty-five agreed. The Dialogues were intended to meet the following goals:

- To probe selected answers to Survey Phase 1 questions, in which clarification or further information was desired.
- To explore with Expert Panel members crucial topics to be included in the Workshop agenda.
- To prepare the Expert Panel member to speak on or moderate a panel.

Questions for each Dialogue were unique to the respondent based on the respondent's Survey and the intention of the Dialogue, as mentioned above.

The Dialogues were conducted on the Zoom teleconferencing platform or on the phone, from Oct 2nd through Dec 3rd, 2019.

No compensation or incentives was offered or given for participation in the Dialogues.

5 Survey Results

Except for question 1, this section outlines each question, as it appeared on the Survey, and then presents a summary of the aggregated responses for each question. Question 1 asked for respondents' name, email address, industry sector, organization name, department name, department size, respondents' position, and number of direct reports.

For a complete list of the Survey questions and detailed responses, please refer to Appendices D through K.

A total of 75 responses were collected. Figure 3 shows the distribution of respondents across a diverse set of industry sectors. ***It should be noted that not everyone answered every question.***

Sector	*Count*
Information Technology	31
Telecom/Communication	7
Healthcare	5
Technology/Computer	4
Education	3
Banking	3
Industrial	3
Government	3
Automation	3
Technology Services/Consulting	2
Software	2
Education Tech	2
Professional Services/Consulting	2
Environmental Eng. Consulting	1
Manufacturing and Design	1
Media	1
Energy	1
Transportation	1
Total	*75*

Figure 3 – Industry Sector Of Survey Respondents. N=75

Q2.1- "Considering the new hires in your organization this year, how prepared are they in each of the following skills? Also, please identify which are the top 5 most important skills in the list."

Responses were selected from a predefined list. Of the ten skill categories shown in Figure 4A, "analytical skills" and "judgment for decision making" were chosen as top skills by the highest number of respondents. These were followed by "collaboration," "creativity" and "cognitive flexibility." "Forecasting" and "negotiation skills" were selected least frequently as one of the top five skills desired for new hires. Selection of "customer service skills," "leadership," "computation," "data skills," "design," and "people management" were also selected as shown.

As depicted in Figure 4B, across all skills, respondents rated preparedness highest in "computational skills," "collaboration skills," "analytical skills," and "data skills" (average ratings of 5.5, 5.1, 5.0, and 5.0, respectively, on a 7-point scale, in which "7" indicated "very well prepared"). "Negotiation," "forecasting,"" people skills," "leadership," and "design" were

rated lowest on preparedness (3.4, 3.8, 3.8, 3.9, and 4.0, respectively). “Creativity,” “judgement” and “decision making,” “cognitive flexibility,” and “customer service skills” were rated in between these others (4.7, 4.5, 4.5, and 4.3, respectively).

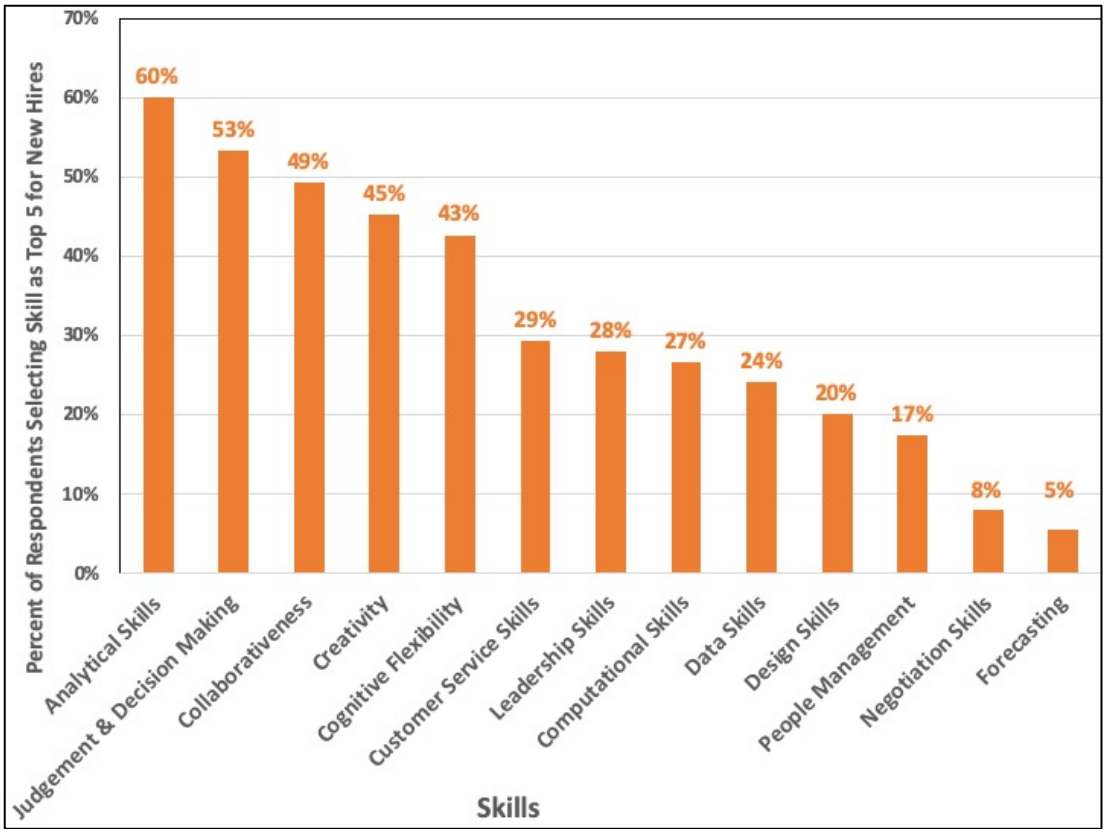


Figure 4A – Percent Of Respondents Selecting Skill As One Of Top 5 For New Hires. (N=75)

Skills	***N***	***Average Ratings of Level of Preparedness***
Computational Skills	67	5.5
Collaborativeness	71	5.1
Analytical Skills	70	5.0
Data Skills	68	5.0
Creativity	68	4.7
Cognitive Flexibility	69	4.5
Judgement & Decision Making	71	4.5
Customer Service Skills	70	4.3
Design Skills	69	4.0
Leadership Skills	67	3.9
People Management	67	3.8
Forecasting	65	3.8
Negotiation Skills	67	3.4

Figure 4B – Average Ratings Of Level Of Preparedness Of Skills (1:Very Poor, 7: Very Well)

It is important to note that of the five skills considered most important, four are Foundational Skills (Figure 1), and only one, analytical skills, is a Specialized Skill. These top priority skills are the same that the workshop participants identified as Foundational Skills, meaning that they provide the foundation upon which technical and specialized skills are built.

Q2.2 - "What other critical skills not listed above are considered important and the new hires' preparedness in these skills?"

The answers to this fill-in question varied and included a wide spectrum of skills. Figure 5 shows the ten skills most frequently mentioned. "Communication" was the skill most frequently added by respondents to the list of skills in Q. 2, with preparedness rated so-so (4.2). A relatively high average rating (5.7) was given to "programming skills", for those who mentioned it.

Of the top ten additional skill mentions, only two – "programming" and "AI/Machine Learning" – would be considered Specialized Skills. The other eight – including "communication," "adaptability," "empathy/emotional intelligence," "curiosity," "learning skills" (learning how to learn well), "innovativeness," "time management," and "project management" – would be considered Foundational Skills (Figure 1). On these, preparedness ratings ranged from 3.2 to 5.7, on a 7-point scale, with an average of 4.4.

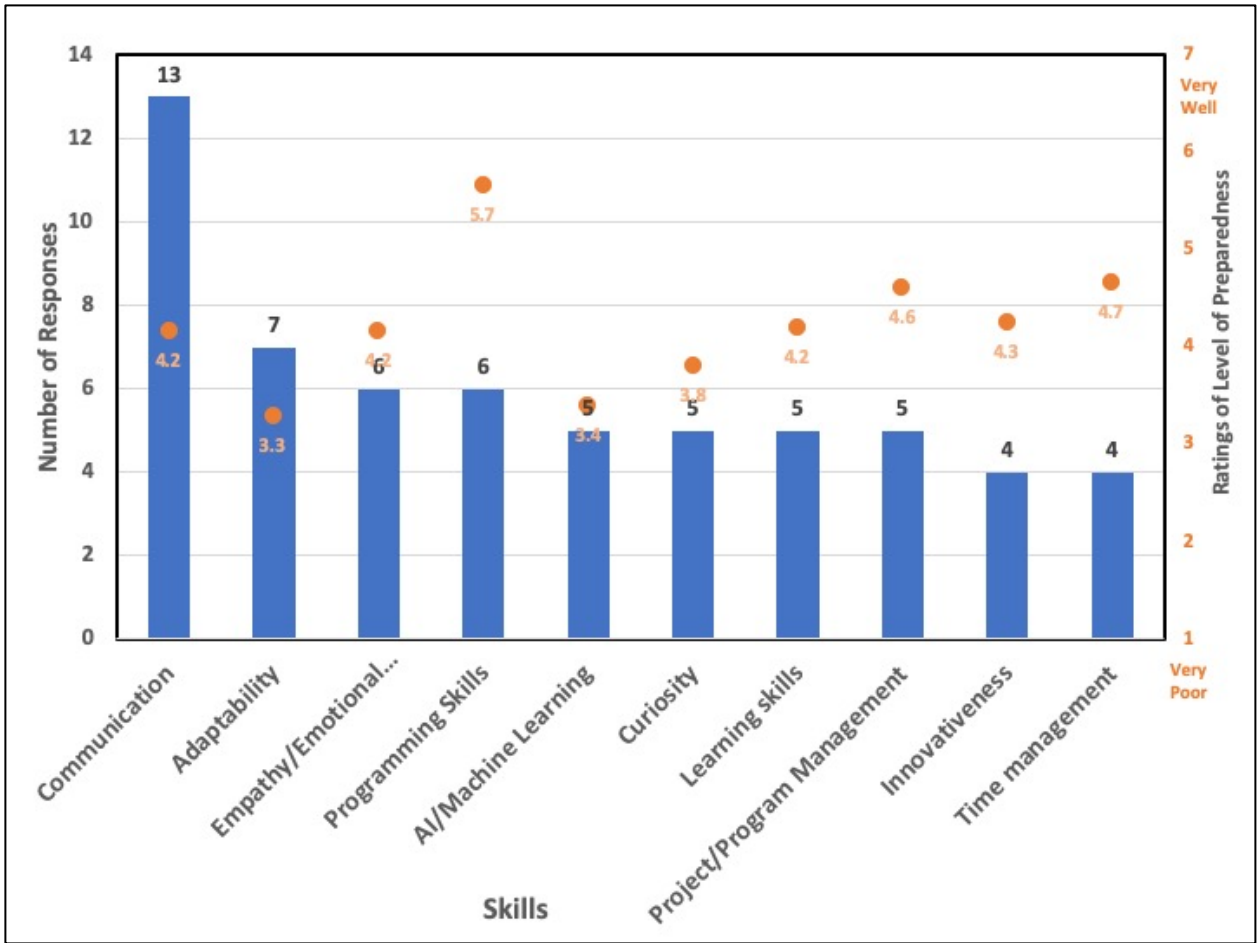


Figure 5 - Other Critical Skills For New Hires And Average Rating Of Level Of Preparedness On Those Skills.

Q 2.3 - "How do you think the skills, their importance, and new employees' preparedness will change five years from now? "

The respondents provided many insightful qualitative answers to this open-ended question. Here are a few (see all the responses to this question in Appendix E):

- "Technologies will continue to change rapidly. What we learned in school will get outdated [quickly]. There has to be a lot of focus on continued education in the workplace. Employees have to be flexible and adaptable to learn new skills quickly to stay relevant."

- "I believe there's a great inversion happening. For all the focus on technical ability, the real shift over the next five years will be back to interpersonal skills. A.I., machine learning will offload most technical skills and future problem-solving will require the ability to collaborate across different personas."

- "I think the skills will continue to evolve based upon the needs of the industries. There are jobs that exist today that didn't 10-15 years ago and with those new jobs, comes along a nuanced skill set required to do that work. In addition, how we learn today,

absorb information and use information to complete our personal and professional work continues to evolve, thus a new employees' preparedness will have to morph to keep pace with the new environment."

Q 3 - Question 3 consisted of four related open-ended questions. The respondents provided many insightful qualitative answers to each of the questions. The detailed responses to each of the questions are listed in Appendix F. To show a few examples of the answers, below each question is followed by a few of the answers:

Q 3.1 - **"**Thinking about recent graduate hires in your organization, especially those going into a project/corporate management job or career path, what are your organization's expectations of skills?"

"I expect them to be able to quickly pick up new technologies and be confident in taking on tasks in domains they haven't seen before, knowing when to seek help and how to effectively engage others both in learning the processing and formulating their results."

"Maturity, comfort with technology and analytics, curiosity and interest to continuously learn."

"Strong business acumen, project management skills, communication skills, people management skills. Good understanding of technical areas like data science and AI and ability to manage experts in those areas."

Q3.2 – "How will these expectations of skills for new hires in a project/corporate management job or career path change 5 years from now?"

"Change is the only thing that is constant. Those that can adapt to change quickly will survive. Others will struggle."

"Adapting more and more technology into the work environment."

"Will not change."

Q3.3 – "Thinking about new hires in your organization, especially those going in a strictly technical job or career path, what are your organization's expectations of skills? (emphasize differences from above.)"

"Develop organizational awareness, be able to understand the dynamics of power and how and who makes the decisions. Figure out how best to influence the decision-makers with rational arguments, facts, and analysis. Communication is key."

"Delivering high quality projects - technically strong in design, computation, analytical skills, up to date on industry regulations, resourceful, problem solving skills."

"To have a more inclusive mindset and design not only for one segment / one demographic / one population but also think how underserved groups (visually impaired, disabled, old, veterans, divorcee, single parent etc.) could be included in the technical design."

Q3.4 – "How will these expectations of skills for new hires in a strictly technical job or career path change 5 years from now?"

"Having a technical skill set, alone, will not be enough. When machine learning offloads 80% of the 'work to be done' only complex problems, ones that require collaboration, will be the responsibility of the new hire."

"Applied Computer Science will continue to become the most prominent growth area for STEM graduates, so I would expect CS programs will increasingly need to focus on applied skills to complement and exercise the theoretical underpinnings that have been the hallmark of traditional CS programs."

"As more tasks and activities get automated, the "human" skills will play a bigger role. Also training the algorithms to "behave" will be very important (inclusive and human-centered design, bias reduction, ethics, security etc.)."

Q 4.1 - "Are non-technical employees in your organization required to have programming/computing expertise?"

Q 4.2 - "What is the required degree of programming/computing skills and knowledge for non-technical employees in your organization?"

Q 4.3 - "Please specify required programming languages and computing environment for these non-technical employees."

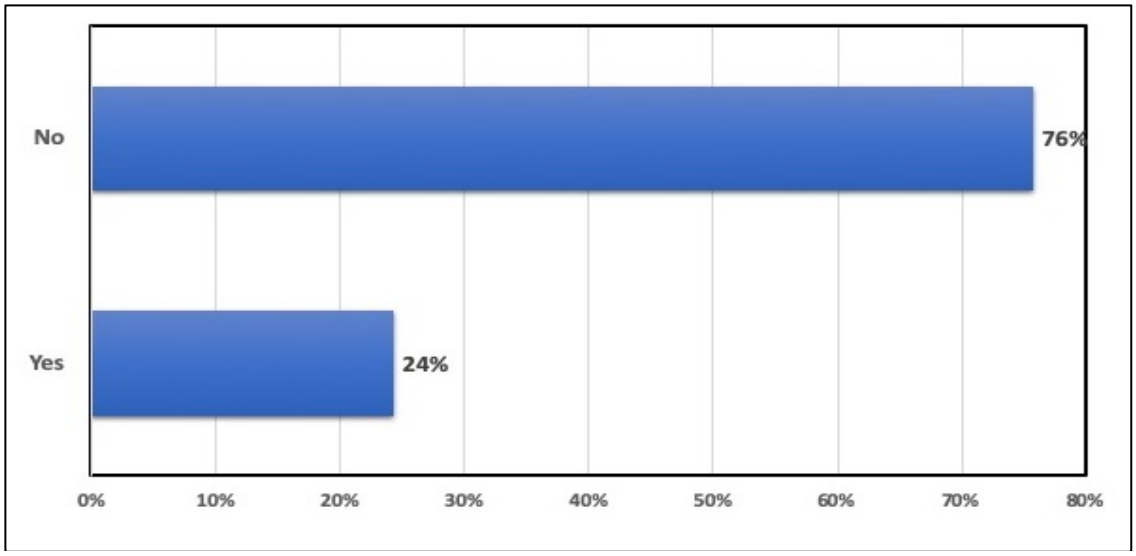


Figure 6 – Percent Of Respondents Indicating Whether Non-Technical Employees Were Required To Have Programming/Computing Expertise. N=70

As depicted in Figure 6, 76% of the 70 respondents answered "No" to Q4.1, indicating their organization does not require non-technical employees to have programming/computer expertise; and 24% responded "Yes." For those who answered "Yes," they were asked further in Q4.2 for their ratings of the required level of programming and computing expertise for non-technical employees. The average rating was 3.75 on a 7-point scale (limited to expert level).

Q4.3 solicited specific requirements for the programming and computing environment. The responses varied and included understanding programing concepts, spreadsheet, presentation software, statistics, web page development, dev-ops, Python, R, SQL, SPSS, C++, BASH, CICD, Java, cloud computing, and even one respondent identified use of GiTHub[3].

Q 5.1 - "What Tools or types of Tools are new technical hires expected to be able to use immediately after hiring and what tools your organization prefers to train new hires to use? (Select multiple, leave blank if not applicable.)"

Figure 7 shows a list of tools commonly used in entry-level STEM jobs. Respondents were asked to indicate whether their organizations expect new hires to come prepared with the working knowledge of those tools and if their organization prefers to internally train their new hires on those tools.

As shown in Figure 7, the majority of respondents prefer new hires to come well-versed and able to use tools such as "spread sheet," "presentation," "analytics," "collaboration," "database tools," "project management," and (marginally) "statistics." While this expectation is relatively low for "cognitive assistant" and "virtual reality" tools, those that expect new hires to be able to use these skills prefer to internally train the new hires in the use of these tools. It is interesting to note that while 51% of respondents said they expect new hires to come to work knowing how to use "project management" tools, 40% prefer to train them internally. One might infer that organizational practices around the use of "project management,"

[3] GitHub, Inc. is a company that provides hosting for software development version control. https://github.com/

"collaboration" (35% prefer to train internally) and "cognitive assistants" (35%) have strong company-specific preferences and mandates.

Figure 8 lists the brand names of the tools identified as expertise expected for new hires. See Appendix G for more details. It is important that universities seeking to educate students with the tools that are relevant for 21st-century jobs consider these industry preferences.

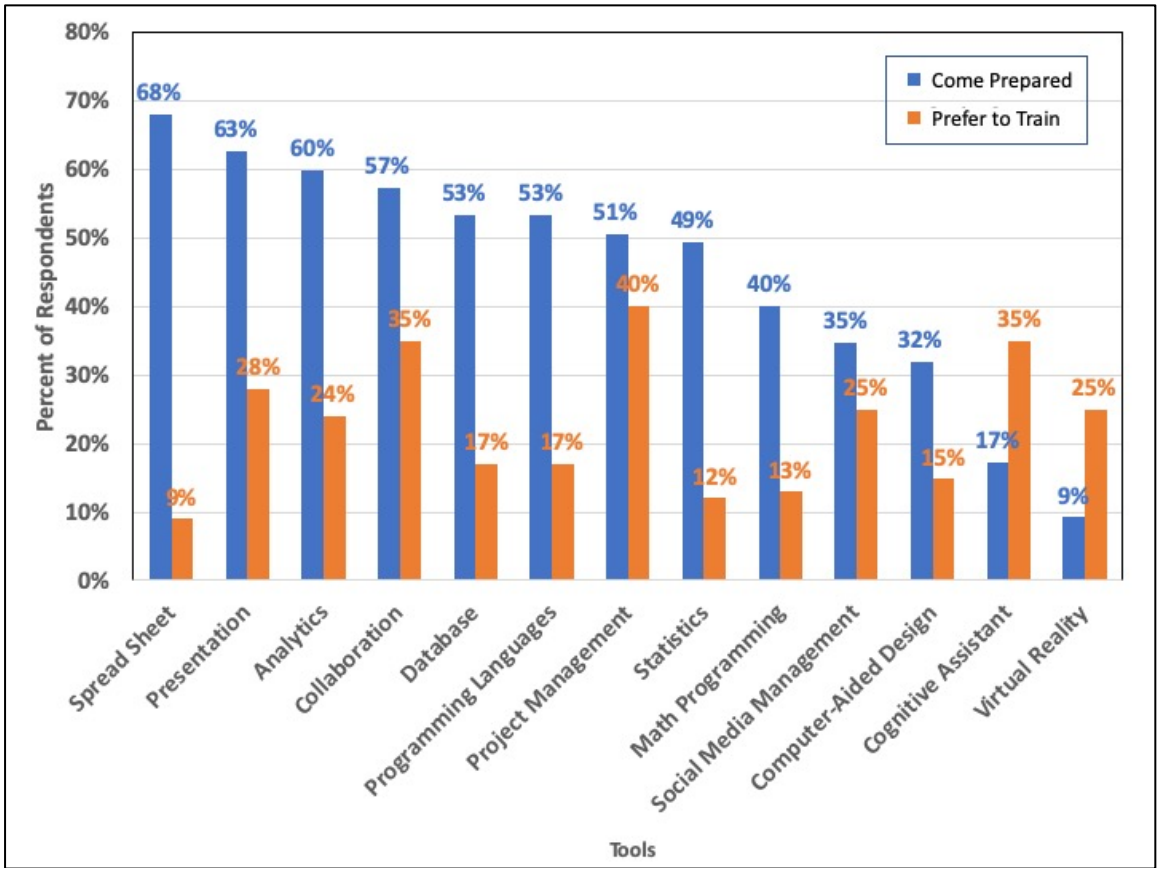


Figure 7 - Percent Of Respondents Indicating New Hires Expected To Come Prepared To Use Tools Vs. Prefer To Train On Tool. N=75

Tools & Type of Tools	*Brands*
Spread Sheet	Excel, Google Sheet, …
Presentation	Powerpoint, Google Slides, …
Database	DB2, Oracle, MySQL, SQLite, MongoDB, …
Statistics	SPSS, R, Excel, …
Analytics	SPSS, R, Google Analytics, Adobe Analytics, Watson, …
Math Programming	SPSS, R, Matlab, …
Programming Languages	Java, Python, Javascript, C++, Go, …
Computer-Aided Design	Adobe X, …
Collaboration	Slack, Confluence, Agile/Scrum, …
Cognitive Assistant	Watson Assistant, Hoot, Google Call Center Assistant, …
Project Management	Git, Phabricator, Clubhouse, Asana, …
Virtual Reality	
Social Media Management	Twitter, Linkedin, Facebook, Instagram, Sprinkler, Press Releases, …

Figure 8 - Examples Of Tools & Type Of Tools And Top Of Mind Tool Brand Mentions.

Q 6.1 -"How well does the academic credit and degree structure of higher education prepare students to work in your industry upon graduation?"

Only 21% of respondents rated the academic credit and degree structure as preparing students well for work in industry (“6” or “7” rating on a 7-point scale). Fourteen percent (14%) indicated the preparation was not at all good (“1” or “2” rating). Sixty five percent (65%) rated the preparation as so-so (“3” ”4”, or “5 “ratings). A few comments provided in the open-ended fill-in following this question clarified that this rating may depend on the specific university, the degree program, and/or on the job, and they indicated that some universities do a better job than others.

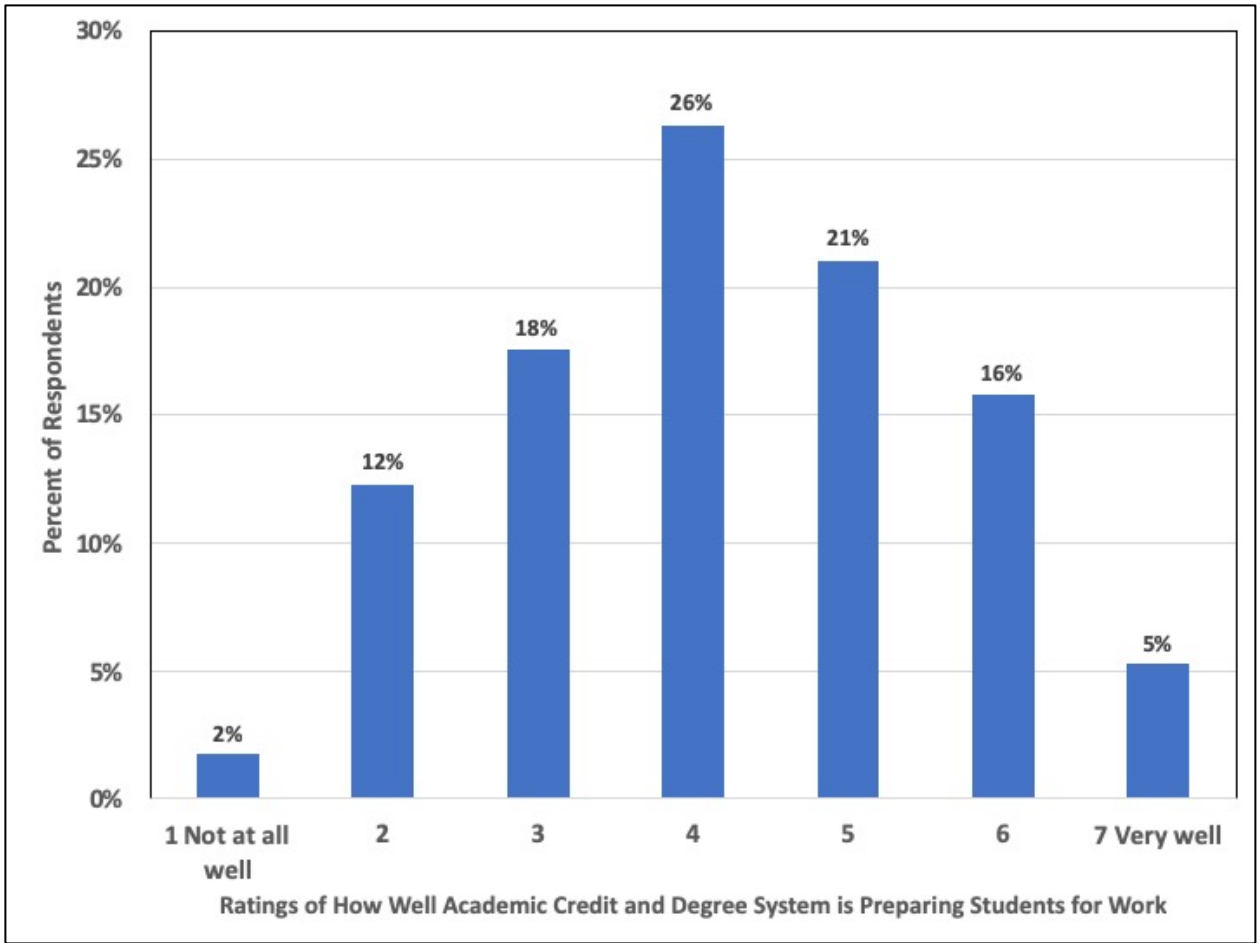


Figure 9 - Percent Of Respondents Indicating How Well Is The Academic Credit And Degree Structure Of Higher Education Preparing Students To Work In Their Industry Upon Graduation. N=57

Some of the survey respondents, who agreed to participate in post-survey Dialogues, were asked to expand on their answers to this question. Here, a few comments are listed:

- "There is no linkage between job requirements and education."
- "Universities are behind in teaching with the latest technology."
- "More often than not, universities are teaching tools that are obsolete or irrelevant to industry."
- "University programs with experiential components, internships, and practical experience produce better candidates."

Additionally, several respondents said that universities can do a better job in educating communication skills (verbal & written), professional and public speaking, collaboration, creativity, and other soft skills.

For all responses to this question, please see Appendix H.

Q 7.1 - "When making hiring decisions, does your organization consider verifiable skills certification/badging achievements of applicants as compliments to academic degrees?"

Q 7.2 - Please expand on successes, opportunities, and challenges, if applicable.

As shown in Figure 10, the majority of respondents (72%) said that in hiring decisions their organization has considered badging and certification in addition to academic degree programs.

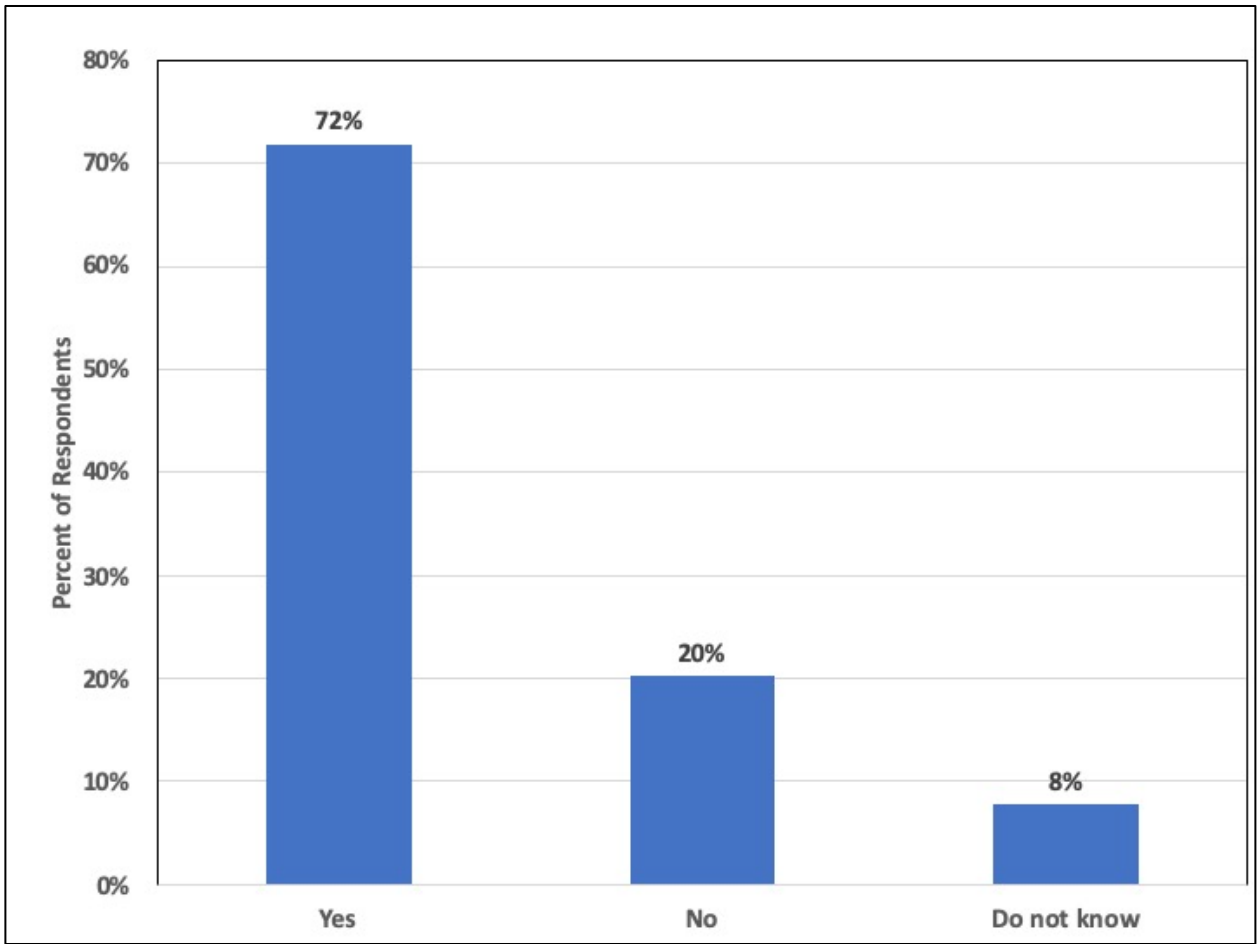


Figure 10 - Percent Of Respondents Indicating Whether Their Organizations Had Ever Considered The Use Of Verifiable Competency And Skills Certification/Badging In Relevant Job Function Areas As Complement To Academic Degrees And Preparation In Hiring Decisions. N=64

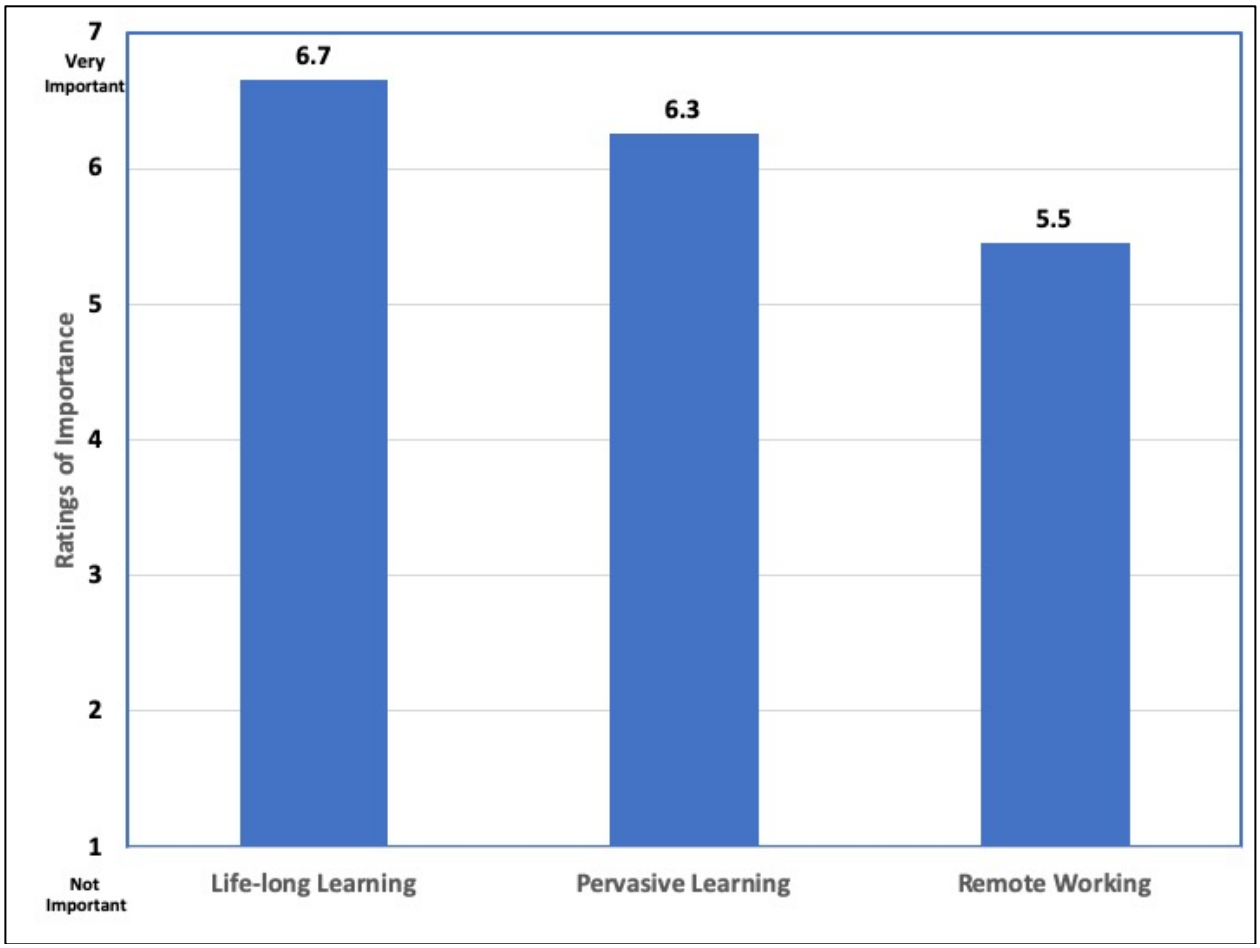
According to open-ended comments from some of the survey respondents to Q7.2, college degrees carry more weight, but certifications are becoming more acceptable and important as well, especially in skills specializations in which a micro-learning format of these programs is conducive to rapid reskilling and upskilling. Also, some respondents mentioned that certificates and badges tell a story beyond a four-year degree. In addition to showing competency, evidence of micro-badges can indicate that the person has initiative and is motivated to learn

on their own; it also can be interpreted as a demonstration of a commitment to life-long learning. A given example of an industry standards badging program is that of IBM[4]. Detailed comments to Q 7.2 are shown in Appendix I.

Q 8 - How important are the following (life-long learning, pervasive learning, and remote working/learning) in your industry five years from now?"

As depicted in Figure 11, respondents consider all 3 types of learning as important, and on the 7-point scale of "not important" being "1" to "very important" being "7", "life-long-learning" (6.7) and "pervasive-learning" (6.3) are viewed as more important than "remote working/learning" (5.5).

It is important to emphasize that result of this research were collected before the impact of COVID-19 pandemic supercharged the need for remote working and learning. Because of the pandemic, many educational institutions and businesses have switched to remote modes of learning and working. At the time of this writing, the long-term impact of this change remains uncertain and warrants further study.



[4] Example, IBM badging program - https://www.ibm.com/services/learning/badges (accessed April 3, 2020)

Figure 11 – Ratings Of Importance Of Various Modes Of Learning. N=64

Q 9.1 - "Has your organization been able to access a sufficient number of US university bachelor's degree graduates from Science, Technology, Engineering, and Math (STEM) programs (e.g., BS Biology, BS Computer Science, BS Math, etc.) as job candidates over the past few years?"

As shown in Figure 12, while more than 70% of the respondents believe that the supply of STEM graduates from US universities is adequate (average adequacy rating of 4.67, on a 7-point scale, in which "1" indicates "not adequate at all" and "7" indicates "very adequate"). Further dialogues with members of the Expert Panel revealed, however, that their organizations are having a difficult time finding sufficient US candidates and have to rely on students with H1B visas to satisfy the demand for new hires. Several respondents raised the issue that not enough of the STEM graduates are American. Therefore, the sufficiency issue of American higher education's preparation of qualified new hires for STEM jobs is more complex than simply whether or not US colleges and universities are educating sufficient numbers of students in STEM.

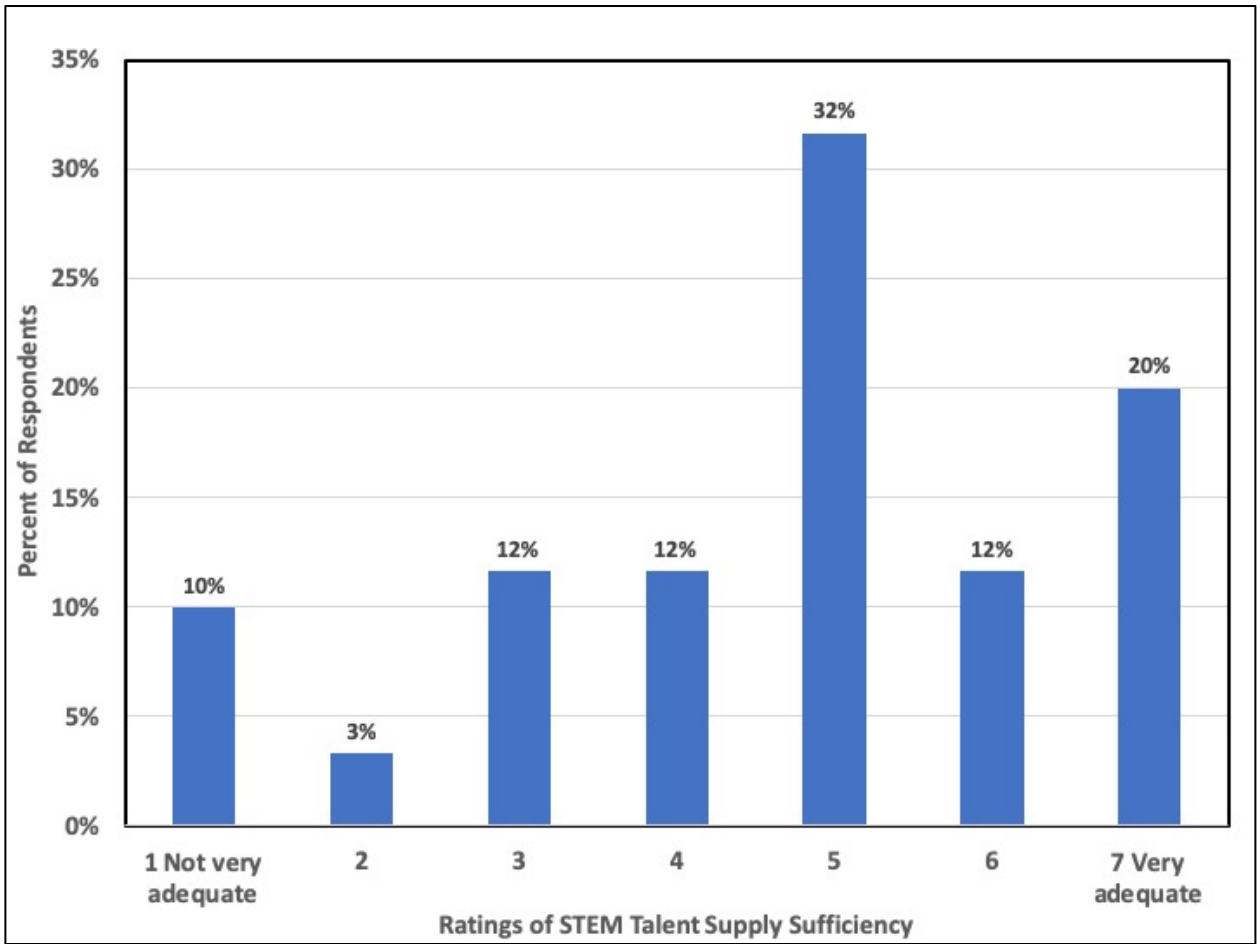


Figure 12 - Percent Of Respondents Indicating Whether Their Organizations Have Been Able To Access A Sufficient Number Of US University Bachelor's Degree Graduates From STEM Programs As Job Candidates Over The Past Few Years. N=60

Q 10.1 – "Please provide any additional comments and questions about the workforce, your industry/organization requirements, and the road ahead in the next five years."

The last question in the survey gave the respondents a chance to provide free form comments about the survey themes. For all the responses, please see Appendix K. Below a few:

- "It's really important that we train a workforce with practical computer skills ranging from traditional Computer Science to effective coding on the latest tools to more generic IT/DevOps skills like AWS certification so there is a larger set of qualified candidates spanning a range of skill areas. Apprenticeship programs would help."

- "I would like to see more diverse candidates in the hiring pipeline. I truly believe diversity increase business agility. However, in STEM area, I still have very small section of the pipeline and that makes building my diverse workforce challenging. I have about 10 direct reports (Sr. Directors and Directors) and about 300 people in my organization. We have a global team including Silicon Valley, Singapore, and Warsaw(Poland)."

- "There is growing polarization of labor-market opportunities between high- and low-skill jobs. The development of automation enabled by technologies including robotics and artificial intelligence brings the promise of higher productivity (and with productivity, economic growth), increased efficiencies, safety, and convenience. But these technologies also raise difficult questions about the broader impact of automation on jobs, skills, wages, and the nature of work itself. We will continue to see automation in the recruiting space. Artificial intelligence interviews are already taking place, and I foresee this expanding as a tool to make the recruiting process more manageable for employers. This will require individuals to expand their interview skills to become comfortable in an already high-stress situation with the added challenge of speaking to a machine."

In Summary, the key takeaways from the survey responses encourage accelerated, earnest responses from higher education leaders and their institutions as outlined below:

- Rapid technology advances are changing the nature of jobs, resulting in jobs that are driving demand for new skills.
- Universities are lagging behind in teaching undergraduates some of the skills needed for industry entry-level jobs. These skills span a broad range that can be categorized as Specialized Skills (technical in nature), and Foundational Skills (general in nature). While industry is interested in both categories of skills, its view is that undergraduate hires come to work well-prepared with Specialized Skills, but not well prepared with Foundational Skills.
- Industry leaders advise higher education leaders to provide more Foundational Skills learning opportunities to students.

- Badging and other skill verification approaches are considered by industry as augmenting, and not replacing, the 4-year degree programs.
- "Life-long learning" and "pervasive learning" are viewed by industry leaders as very important.
- A basic level of computing skills is required, even for non-technical jobs, in STEM work environments.
- Industry demand is increasing for candidates that have more practical experience through internships, and co-ops.
- Finally, US universities are not producing enough American STEM graduates to satisfy industry needs, resulting in industry dependency on new hires with H1B visas.

6 Workshop

The results of the Workshop, held on Dec 10, 2019, Santa Clara, CA include a summary description of each of the presentations, a summary description of the panel discussions, followed by nearly-verbatim reports of the panel discussions, and of the breakout sessions. **Modifications have been made to the original transcript or message only to improve readability and clarity, with diligence to maintain the integrity of the speakers' messages.**

6.1 Workshop Participants

A total of 36 individuals participated in the Workshop (Appendix B). The workshop participants included:

1) the 24 members of the Expert Panel,
2) the project PI, Co-PI and two senior personnel,
3) three faculty members from San Jose State University, and one from Arizona State University, all with rich industry perspectives,
4) two San Jose State University students to assist with the logistics of the Workshop,
5) two representatives from NSF.

Additionally, one guest, an ISSIP Board member, also a Fellow at Japan Science of Technology Agency, attended the Workshop as an observer (fully on his own expense).

All of the workshop participants were invited via email. Of the 35 members of the Expert Panel, 28 accepted to participate in the Workshop. Of those 28 Expert Panel members who accepted the invitations, 24 participated in the Workshop; 4 had to cancel last minute due to unforeseen circumstances. All the others indicated in items 2-5 above participated in the Workshop.

The two students (#4 above), the two senior personnel, and the two CO-PI's were compensated for their time to participate in the Workshop. The other participants nor the one guest were compensated. No travel reimbursements were made to any of the participants or the guest.

6.2 Workshop Presentations

6.2.1 Welcome

Yassi Moghaddam, Executive Director, ISSIP, and Professor Stephen Kwan, Professor Emeritus, and former Associate Dean, Lucas College and Graduate School of Business, San Jose State University, opened the Workshop and welcomed and thanked the participants for taking the time to participate. Moghaddam explained how ISSIP, with more than 1000 members across industry and academia, catalyzes industry-academia-government collaboration in cutting edge research, best industry practices, innovative educational models, and policies that promote advancement of innovation and smart service ecosystems by fostering professional thought leadership of its members through joint conferences, workshops, publications, members mentorship, and awards globally.

Moghaddam then noted that the perspectives of this industry panel on STEM education for the future will be a crucial part of a wider national conversation that NSF is stimulating between industry and academia about what the future of education and training should be down the road, considering that the future of work is going to be significantly different.

She then outlined the agenda for the day (Appendix A) and stated that the goal of the 1-day Workshop was to "generate actionable ideas aiming to close the gap between undergraduate education and employment that would lead to a thriving 21st century workforce in our nation."

Finally, she invited Dr. John Jackman, Division of Undergraduate Education, Education and Human Resources, NSF, to provide a perspective on NSF's overall rationales and goals for supporting this project.

6.2.2 Goals & Rationales of the Workshop

John Jackman, NSF: To give the workshop participants vital context for the goals of the Workshop, Dr. Jackman described the various NSF initiatives in the Division of Undergraduate Education, Education and Human Resources (EHR) that aim to:

- Prepare the next generation of STEM professionals.
- Attract and retain more Americans to STEM careers.
- Develop a robust research community that can conduct rigorous research and evaluation that will support excellence in STEM education and that integrates research and education.
- Increase the technological, scientific, and quantitative literacy of all Americans so that they can exercise responsible citizenship and live productive lives in an increasingly technological society.
- Broaden participation (individuals, geographic regions, types of institutions, STEM disciplines), and close achievement gaps in all STEM fields.

EHR's objective is to address the current and future needs of industry regarding the STEM workforce and to anticipate the new skills and knowledge that will be needed for new jobs when AI and automation become pervasive in the workplace.

6.2.3 Overview of Industry Stakeholder Survey Results Received as of Dec 10, 2019

Dr. Stephen Kwan Professor Emeritus, San Jose State University, presented the results of the Survey Phase 1 collected Nov 1-30, 2019, during Phase 1 of the project. The results presented in this session were based on 23 total responses, the total number of responses gathered by the end of Phase 1. The complete detailed Survey results, including the results of both Phase 1 and Phase 2 are provided in Section 5 of this document.

6.3 Panels

6.3.1 Panel 1 – Perspectives from IT, Media and Entertainment, Telecom, Financial Services

Moderator: Susan Cantrell, formerly Innovation and Research Lead, Accenture

Panel speakers:

- **Naguib Attia, VP Global University Programs, IBM**
- **Nitin Badjatia, Head, Product Strategy, ServiceNow**
- **Guy Berger, Principal Economist, LinkedIn**
- **Yun Freund, VP Engineering, Equinix**
- **Alka Roy, Product and Technology Leader, AT&T**
- **Guru Sethupathy, Head of People Strategy and Analytics, Capital One**

Panel 1 Summary - In this panel, industry leaders representing high tech, media, telecom, financial and professional services shared their perspectives about job opportunities in STEM fields for today and for the foreseeable future. According to these experts, STEM jobs are growing in many areas of STEM – including artificial intelligence, cybersecurity, cloud computing, data science, IoT (Internet-of-Things), open-source, and blockchain. Additionally, jobs in emerging fields such as quantum computing, biomedical, control systems, robotics, telerobotics, augmented reality, and virtual reality are already present today and are expected to grow in the future. Specialized Skills required for these current and emerging jobs are constantly changing as some technologies continue to advance, making others obsolete; and therefore micro-learning modes of education are better suited for developing these skills than traditional academic degree programs. In order to facilitate rapid response to the evolution of reskilling needs, higher education leaders are advised to re-focus the 4-year STEM degree programs to provide the broad Foundational Skills that are essential over the lifespan of careers and actually prepare learners for life-long micro-learning.

The panel also made a distinction between STEM jobs and STEM degrees. While it is anticipated that the majority of good-paying entry-level jobs will be in STEM, according to the panel, not every one who is preparing for the STEM job market needs to be a graduate of a STEM academic degree program. That being the panel's view, higher education leaders are

advised to think about how to prepare both STEM and Non-STEM students for the new STEM jobs. Accordingly, the panelists stated that it would be a mistake to focus on STEM education at the exclusion of liberal arts. The view of several panel speakers was that liberal arts graduates with a baseline level of "digital skills" will be in greater demand in the coming years, particularly as AI becomes more pervasive in the workplace. Also, many of the Foundational Skills such as abstract thinking, conceptual problem solving, human-centered design, and creativity are fostered by a liberal arts education. Finally, the panel characterized new STEM graduate hires fairly well-prepared with technical Specialized Skills, but often lacking the Foundational Skills necessary to perform well in those jobs and beyond.

Susan Cantrell opened the panel highlighting context and macro-trends in the future of work and described how those trends could impact the young STEM talent entering the workforce.

- Who performs the work is radically changing:
    - New work models are emerging. Smart machines have entered the workforce. There are "digital colleagues" that are doing much more than automating the tasks. They are collaborating with human workers and reconfiguring jobs as a result.
    - [Non-routine] Human skills are increasingly becoming more important since routine tasks are being automated away. Creativity, the ability to constantly learn and reinvent yourself, and adaptability are all becoming very important.
    - People are collaborating actively not only with smart machines, but are also collaborating with people beyond the borders of their organization.
    - New workforce models, consisting of ecosystems of freelancers and gig workers, are emerging.
- How work is being performed is also radically changing:
    - Iterative rapid problem-solving processes are replacing sequential cascaded linear processes.
    - Management models are moving away from traditional structures to networks of highly agile, and virtual teams.
    - As the pace of change continues to speed up, the nature of skills is also fast-changing. We see the rise of hybrid jobs; skills that used to be apart in different jobs are now being combined, for example, programmers needing design skills. "The diminishing half-life of skills" is estimated to be 5 years now (Thomas, et al., 2011). According to a study done by Dell (2018), 85% of jobs that today's students will do in 2030 don't even exist yet. In this context, how do we even know how to educate our STEM workforce for a future that is so rapidly changing?

Cantrell then introduced each of the panel speakers and asked each to offer a 5-minute opening statement including a summary of how they are involved in future workforce skills development.

Alka Roy, Product and Technology Leader, AT&T (Telecom, Media & Entertainment) -
I am part of an AT&T innovation center. We are working on content, the impact of technology in entertainment, AR/VR, and more. I am also working with the Linux Foundation Trusted AI Committee on a "responsible innovation" framework with experts from other companies, UC Berkeley, and Stanford, because it is important to organize for innovation not only inside, but also outside of each of our own industries and company affiliations.

I don't worry about technical skills for the future generation. What I do worry about is what value systems [not just skills] we are handing to the future generation, so when they are making decisions using advanced technologies, they would actually make responsible decisions. This requires not just teaching skills, but values.

Naguib Attia, VP Global University Programs, IBM (IT, Professional Services) - There is a timeline mismatch between industry and academia. Academia works on a 4-year timeline; in contrast, industry works on a 6-month one. Academia is not producing industry high-demand talent in **Artificial intelligence, Security, Cloud, IoT, Data Science, Blockchain, Quantum, Design thinking,** and **Open Source** fast enough. Universities have to reinvent themselves around these new science and technologies. And to do that they have to engage more with industry.

Guru Sethupathy, Head of People Strategy & Analytics, Capital One (Financial Services) - Machine learning is transforming a broad swath of jobs, and it is important to look at how we are going to transition the workforce from the current state to a future state. If you think about which skills and mindsets will have more leverage, first **abstract thinking** and **conceptual problem solving** are going to have huge leverage going forward. To precisely understand causal mechanisms in various phenomena, to have mental models of these phenomena, and to be able to map to those mental models for varying contexts will all become very important. That is where we see creativity coming into play.

The second piece is **probabilistic thinking**. In the future, everyone has to be better in probabilistic thinking. With the proliferation of data and analytics, those individuals with strong probabilistic thinking would be able to make better decisions, and the knowledge economy relies on better **decision-making**.

The third area is **values and ethics**. That is something I don't see currently included in the purview of AI. Human judgment is going to shape how values will be incorporated going forward, and it is going to be a key differentiator in outcomes.

And finally, the fourth piece is the skill to **learn fast and adapt.** There are primarily three type of learning:

1. **Learning new mental models –** This requires establishing new neural pathways in your brain; It doesn't require any rewiring. That is the easiest form of learning.
2. **Updating mental models -** If you have a view of the world and you learn new data, how intellectually adaptable are you to rewire your mental models with a new map of the world? This type of re-learning requires rewiring your brain. Humans are not good at that. If you ever try to change someone's mind with data, it is really hard to do. Those folks who are comfortable with their own intellectual humility will be exceptional.
3. **Learning new Habits** - Then the last piece is learning new habits. It is hard to learn new habits, and those who are able to do that quickly are going to be successful.

The 2nd and 3rd type of learning are harder to do, and those who are able to do these quickly will have an edge.

Yun Freund, Sr. VP Engineering, Equinix (Internet) - The technology space is moving very fast. Today we are hiring Cybersecurity and ML experts. In 5 years, new technologies will arrive (e.g. Quantum). Learning new technologies quickly is important but **learning to learn quickly** is the basic skill that we need to teach our kids. We should arm our next generation with the ability to manage constantly evolving trends. **Being flexible** and **learning to learn** constantly in order to keep up with the fast pace of change is critical.

Diversity is also very important. We need to make sure we have all voices represented in the whole generation of new STEM graduates. Diversity must be cross-generational as well as cross racial/gender/ethnical lines. Also, **cross-domain skills** are also important. Data science/ML/AI are enablers and offer a reasonable place to start; but if you are a data scientist, you must be able to apply your knowledge to a sector like healthcare, power, or energy. So, we need to combine data science with domain knowledge.

Nitin Badjatia, Head, Product Strategy, ServiceNow (IT) - I run product strategy for customer workflows for ServiceNow (an up and coming enterprise software company). I have no tech background whatsoever, yet I run product strategy. I think this should be a warning as well as an example of what the future holds. I started in banking, and ended up in Tech. So, we need to adapt to the rapid changes. Every day we learn something new.

In Tech, the value has been in services (vs. goods) for quite some time now, and Tech is cascading this phenomenon across every industry at scale. So, we have to think about skills from **service [thinking]** perspective too. According to Kevin Kelly (2016), we live in a world in which we are forever becoming. Nothing is static any more. What that means is that, we have to **learn constantly and learn fast**. Micro-learning is becoming the norm. ServiceNow's tagline is "We make the world of work, work better for people." The part "work better for people" is what matters today. Back in the day when we made something, it didn't really work well for people (it was cumbersome for people to use). It would take 2 weeks or so for the user to learn how to use something. So, for the jobs of the future **user experience and design skills** are also important.

Guy Berger, Principal Economist, LinkedIn (Internet) - At LinkedIn, I work in the Economic Graph team, which is tasked with measuring, analyzing and projecting the future of work, using LinkedIn Data. A lot of our work is centered around these themes:

- Career pathways using our data
- Impact of AI in other emerging technologies and the workforce
- Globalization/de-Globalization
- Entrepreneurship
- Gig economy

I would like to raise two points.

1. Technology is going to be an integrated part of everyone's job. Therefore, everyone in some respect is going to be a STEM worker. However, not everyone has to be a STEM graduate. We need to think about how we prepare STEM and Non-STEM students for new STEM jobs. Also, we need to think about people who have STEM education, but

not in the form of the 4-year degree. For all of these people, technology is going to be part of their jobs. Therefore, we need to think about educating folks in this context.

2. The second point is that there is an assumption that we have to teach people skills that are super relevant to the workforce. What I worry about that kind of push is that those skills are specialized and will bring high return in short term, but they are also the skills at risk of commoditization and automation. On the other hand, **generalized (work practice) skills**, **soft skills**, **and people skills** are going to be important in the long run and will be in demand regardless of how the demands for specialized skills change. Included in the generalized skills is basic **digital literacy**. These demands may involve **coding**, but not in the way it was done in the past. I am not pessimistic about the future of work. Things are going to change, and the best we can do is to teach everyone **adaptability and resilience,** so when change does hit them, they can adapt.

Cantrell, Q2: What skills in your industry will be more in demand in the future and what are lacking today? What about the importance of liberal arts? Fine arts? Interdisciplinary programs? How deep do we go in terms of specialized skills (if they are going to be outdated in 5 years)?

Guy Berger - The way we should think about it is like a hub. There are broad human capital skills, general skills, and then there are the specialized skills. There is value in educational institutions that prepare people for more **specialized skills,** but it should not displace foundational skills education nor should teaching specialized skills on their own be the core of any education. I think micro-learning or reskilling can work well for specialized skills. In this context, **higher education can focus on providing the broad foundational skills that last, and actually prepare the learner for micro-learning, and then micro-learning for life-long reskilling**.

Nitin Badjatia - Building on this, I like the term “human capital” vs. human resource, resources are fungible, capital is not. Uniqueness of every individual matters. Something that we are looking at in hiring is that building code and designing code are the easy parts of building software. Making the interface and the user interaction model in a workflow as the product interacts with humans is the real challenge. That requires a blend of skills that are **interdisciplinary**. Steve Jobs, 11 years ago, said that there are 3 revolutions. The best phone, the best iPod and the best web browser, but I think there were 5, the 4th was the App store, and the 5th was shipping products without instruction manuals. That required not only engineering skills, but it also a deep understanding of **Human-Centered Design**.

Yun Freund - Universities should focus on teaching **fundamental skills** such as **learning to learn, problem solving, creativity,** etc. **A lot of the specialized advanced skills can be taught in short courses and programs**. And, this can be done in collaboration with industry. For example, for my own organization in Singapore, we had difficulty in getting cybersecurity, machine learning, and big data experts. We worked with the government and a university to establish a 3-month joint program to train experts very quickly on those specialized subjects. After 3-months, we were able to integrate those talents into our workforce. Those individuals were eager to learn and were already highly skilled. **So, as tech moves quickly, these types of short programs through industry-university partnerships can accelerate workforce**

reskilling.

Naguib Attia - I look at it from a practical and strategic viewpoint. Practical refers to the programs academia can implement in 6 months to address industry needs. Strategic is what academia is going to do to produce the new graduates. Academia should address both.

Alka Roy - Adult education, could take a page from the Montessori model playbook which has a structure that requires focus, but it also allows for diversity of thought. When we talk about AI/ML, quantum, etc., how many people in reality need all these skills at a very deep level? With the advent of technology, we think of this as a stackable problem. In reality, only a relatively small group of experts is needed to actually build the tools around these very advanced technologies such as AI/ML, Quantum. However, the vast majority of engineers and experts need to understand these tools enough to build solutions using these advanced tools to solve people's problems. So, the level of depth that you need varies for different groups of people. We don't want our higher education [institutions] to become factories that focus on a narrow set of skills.

Guru Sethupathy - Data Skills are going to be increasingly important. Today I see less value in curricula around for example geometry and trigonometry, than there is around data, probability and statistics. Not everyone needs to be a PhD in statistics but having a broad population that is comfortable around **data** is going to be crucial. Also, facts are going to be important. So, our curricula have to be based on facts. This would mean that skills such as **critical thinking, abstract thinking, conceptual problem solving** will be very important. In the corporate setting, most learning happens on the job (learning by doing). **Learning by doing** builds your mental muscle memory. Therefore, **project-based experiential learning** is going to be crucial.

Cantrell - Q3: Building on what some of you said, that the universities need to reinvent themselves, how do universities close that gap between current state and future state?

Alka Roy - Habits are hard to break, unless something external breaks them. That is true about both people, and organizations. Leave alone the thing that is running fine. In parallel, run iterative interdisciplinary programs to create a new system, and let the student experience inform it. Build a system that feels less like a factory and more like an ecosystem that meets the human needs. Ask students how did their education serve them? Have industry, non-profits, and creative workplaces become part of the educational ecosystem. Create an ecosystem, where the goal is not just a degree. Have more partnerships with the industry. Also, create a pipeline that we can trace back not just for job readiness but can trace back to how our education system is enriching our lives.

Guru Sethupathy - I would do math education differently. **The math curriculum has not changed in decades.** There should be more emphasis on probability and statistics. It is not necessary for everyone to be an expert but having a baseline education around data is going to be very helpful in this economy. Also, **curricula with more emphasis in critical thinking** will be necessary. The other aspect that could be very beneficial is **partnering more with employers**.

Question from Dr. Medina Borja, NSF - NSF is often engaged in this discussion regarding the future of work and STEM education. Sometimes at the end of a panel with university

colleagues, I raise the issue of curriculum change. The response I typically get is that the curriculum is so packed already that there is not enough space to actually teach soft skills, interdisciplinary skills. Then I question whether we really need to teach all the calculus one, two, three, and differential equations 1 & 2 ... Everyone is almost a mathematician at the end of college. I ask if students can instead study more probabilistic thinking or probabilities. And the reaction is always mixed, but the majority is against it. Educators usually say that what makes an engineer is problem solving, and that in fact, calculus is what teaches problem solving.

My question to the industry colleagues is: During your interview process for undergraduate hires, do you really look for someone that has a full-fledged engineering degree with all the calculus, math, and computing? Or do you look for candidates that can be more creative at work?

Additionally, most companies do not hire someone below a 3.5 GPA. That means that you have to have A's & B's for the most part, and that leaves very little room for risk-taking and creativity.

In this context, I would like to hear industry colleagues' reactions to this reflection from academia.

Jutta Williams, Facebook (part of the audience at the time and speaker on the 2nd panel) - My reaction: I failed stats, and now I work in AI. Google hired me; Facebook hired me. That failure led me to look really hard to understand failure. I went to graduate school at Carnegie Mellon. I explained those failures when I applied, and they took that creative answer as a testament to the skills that I built, not despite but because of my failure. There is a misunderstanding around failure [that it is to be avoided], but when you stretch, when you do those risky things, you're going to fail sometimes. I have never hired straight A students. I've interviewed hundreds of people. I don't hire those straight A students because they have no **risk-taking skills**.

Nitin Badjatia - Having hired people over the course of the last 15 to 20 years, in the younger generation, I see an aversion to risk-taking and failing. There is a presumption on their part that they are going to succeed no matter what. This is probably because they have always gotten an award for everything and have not learned the **skill to fail well**. I don't fault the university system as a whole for that, but university is a place where you leave home for the first time, and it should provide you with opportunities to learn this skill.

Cantrell Q3: Naguib [Attia], I really do want to hear your perspective because you said this provocative statement, so tell us about how we need to reinvent.

Naguib Attia - First, what is holding academia back is that they are very slow to change. What takes academia to cover in 5 to 10 years, industry needs delivered in 1 year. In academia, if we need to change even a course, it takes a year or so. In the 21st-centry, a whole set of jobs could disappear in 10 years. Second, in the past, only computer scientists or engineers had to be concerned with tech. Now, data science is used everywhere, medicine, psychology, energy, … Universities need to pay attention to that. We have an academic system that is still very siloed. Thirdly, coming to work in a company, you must be prepared to work in teams. You don't have the option of taking a course instead of a project to be more in control of getting an

A instead of a project. So, the name of the game for academia is change, adaptation and looking for what the market needs.

Guy Berger - Our discussion here is focused particularly on post-secondary education. However, a lot of the literature and the social sciences suggest that the biggest returns to education are in the early pre-K to grade school. I'm not saying it's not worth focusing on university or community college curricula, but we must also take the long view. And so, I would think about what it would take to teach people some of the skills such as **basic skills in coding, math, soft skills,** et cetera, in early education. The time to invest is when people are young.

Comment from Rick Rafey, VP Product Strategy, InOrbit - An informative exercise might be to take these universities and actually profile how the graduates of a given university have progressed, based on the philosophy and the strengths and the approach of that school. In my case, I went to Brown for grad school, and I also interviewed high school kids going to Brown. Brown has a very interdisciplinary approach. When they did their last fund capital drive, it was aimed to hire 150 professors that were specifically recruited around an **interdisciplinary focus**. Now, one in six graduates from Brown are CS graduates but they're coming out with this extra dimension; they find something else they like, and they can take any class they want as pass/fail. This is one example of a proven model, in that you can actually see how it has played out in the workforce.

6.3.2 Panel 2 - Perspectives from Healthcare, Health Insurance, Infrastructure, Transportation

Moderator: Yassi Moghaddam, Executive Director, ISSIP

Panel speakers:

- **Nate Tymann, Director HR, BlueCross, Blue Shield (Healthcare, Insurance)**
- **Jutta Williams, AI Senior Program Manager, Facebook**
- **Randy Iwasaki, Executive Director, Contra Costa Transportation Authority (Government, Transportation)**
- **John Litzinger, Associate VP, Group Director, HNTB (Infrastructure, and Transportation)**

Panel 2 Summary - In this panel speakers representing healthcare, infrastructure, state government, and insurance expressed that their sectors are going through major transformations resulting in increased demand for STEM graduates. They indicated that, in their observation, the STEM graduates enter the workforce fairly well-prepared with technical skills, but they often lack the foundational skills that are necessary to apply those skills effectively to solve business and customer problems. The panelists emphasized the opportunity for higher education to partner with industry to foster experiential job-relevant learning through structured apprenticeship and internship programs that are integrated into university curricula.

Yassi Moghaddam opened the panel by mentioning some of the major changes taking place in the transportation and healthcare industries and their potential impact on jobs and skills.

- Both transportation and healthcare are going through a major transformation. On the transportation side, demand will go up for STEM talent with background in software development, AI, robotics, and more to research, design, develop, test, launch, and maintain these highly sophisticated autonomous machines. This trend has already begun. According to data from Burning-Glass (2017), the scale of job postings in manufacturing including auto industry has already significantly shifted toward software. On the other hand, it is estimated that the jobs of 7 million auto workers and nearly 4 million professional drivers are at risk (Deloitte, 2017). The two trends do not offset each other; nevertheless, this represents both a challenge and opportunity for our education system. On the healthcare side as well, major changes are taking place with advanced technologies and AI in medical imaging, in how surgeries are done, and in how patients interact with doctors, just to name a few. If designed well, AI will likely free up doctors from administrative burdens and enable them to better focus on their patients and in much more empathetic ways. So, we see a tsunami of changes in both of these sectors.

- I often compare the challenge of higher education today to the challenge of public libraries over the last couple of decades. Both higher education and the libraries were created in an age of information scarcity. That no longer is the case. Both of them bring a community of learners together. When I look at the libraries over the last couple of decades, they have gone through a tremendous transformation. Public libraries have recreated themselves as centers where communities come together, share knowledge and learn, and not just a place that people come to borrow physical books. Many libraries today offer meeting spaces to the public. You find a lot of digital media in the public libraries, you not only find rows of computers with access to the internet, but also informed and knowledgeable librarians who guide you in different directions. So, I wonder if higher education were going to borrow a page from the transformation of public libraries playbook, what would it look like? Could faculty transform in a way that they become a conduit between higher education and industry? How could the research approach in higher education change from less emphasis on pure research to more emphasis on applied research?

Moghaddam then introduced each of the panel speakers and asked each to offer a 5-min opening statement including a summary of how they are involved in future workforce skills development.

John Litzinger, Associate VP, Group Director, HNTB - My perspective into new graduate hiring is from the infrastructure consultancy business world. We oversee public infrastructure projects. The jobs in our business evolve over time, but they are very much hands-on with an on-the-job mode of learning. Unlike medical school or nursing school, where graduates go into the workforce fully trained with some professional education and certified licenses, in engineering, you work first to gain experience, then you get licensed by the state. The skills we tend to look for are **communication skills, being curious, whole system thinking, and self-assessment** and **self-awareness**. The whole system/big picture thinking combined with curiosity and self-awareness helps them map out their career and develop the skills necessary

to manage their careers well. If through school projects or internships students can start having this foresight, then they come to work more prepared.

Randy Iwasaki, Executive Director, Contra Costa Transportation Authority - We are a state [of California] agency. We manage a multibillion-dollar budget for a suite of infrastructure projects and programs in Contra Costa County[5]. We work with infrastructure consultancy companies to oversee the infrastructure construction projects. We are also the Congestion Management Agency for our County. In addition, we have created the largest secure autonomous vehicle testbed that is made in the United States[6]. As far as hiring of the next generation, we, [in the Bay Area] know we cannot build our way out of our traffic congestion, and we have to look for innovative solutions to address this issue. We are trying to find new ways of moving people, as well as goods and services. We are looking for mobility solutions as a service. We want to build a smart platform that integrates all of the various transportation options into one platform and analyze the capabilities of the technology and its outcome. We hire people that are **creative**, that have passion for their work. We hire people that are **entrepreneurial**. We hire people that can **make a decision**. We hire people that can take **risks**.

Jutta Williams (JW), AI Senior Program Manager, Facebook - You are probably wondering why Facebook is talking about healthcare. Prior to coming to Facebook, which I only joined in April (2019), I was leading regulatory and privacy-related aspects of Google Health. Prior to that, I was a Chief Compliance Officer for a large integrated health system as an Information Security and Privacy Officer for Integrative Health. I believe we have to think about skills from the perspective of "spiral development methodology (SDM)[7]." SDM teaches you **the skills to look at a problem, iterate a solution, identify where there are fail points, and then create a new strategy.**

Our new graduates today are entering untested waters, whether in healthcare or high tech. With AI and data, we are all entering untested territories that haven't been evaluated. It is a baby that is learning to crawl and walk who will eventually be running really, really fast. The ability to look at things, iterate, identify where there are fail points and then be able to create a new strategy is critically important. And, that is what I am looking for in students who come to me. I want to see the experience of failure so that people recognize when they're failing versus struggling. These are two totally different concepts, and if you can't recognize the difference between struggle and failure, then you are not going to be able to know that you need to stop, evaluate, look at different ways of solving the problem, and move on to the next iteration. The **skill to fail well** is harder to teach by the time we get to work, but it is teachable earlier in life and it is certainly teachable in universities.

Nate Tymann, Director HR, BlueCross and Blue Shield of North Carolina: I am the Director of HR at BlueCross and BlueShield of North Carolina. Prior to that I was with Cisco for 20 years. I would say one of the exciting parts of healthcare is the transformation it is going

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[5] https://www.contracosta.ca.gov/

[6] Gomentum Station, https://gomentumstation.net/

[7] The spiral model is a risk-driven software development process model. Based on the unique risk patterns of a given project. https://en.wikipedia.org/wiki/Spiral_model

through. At BlueCross and BlueShield, I find myself now in this company where there is high customer loyalty, with highly mission-driven people, but with an aversion to change.

From a STEM perspective and recruiting perspective, as we bring in new employees and in particular those straight out of college, we are looking for **leadership skills, openness to continual change, adaptability, and resilience**. In our industry this is really important, as we are going through a transformation from a pay-for-service model to a value-based model. We are changing the way we incent doctors and health care based on the value and prevention of recurring health problems. That is a major strategic challenge. My challenge is to figure out how to train and recruit the type of people that can make this happen and, at the same time, not have all the wheels fall off the bus.

Yassi Moghaddam, Q1: You each have identified a number of critical skills. Looking at your recent undergraduate hires, how prepared do you think the new hires are relative to those critical skills?

Nate Tymann - It depends on which area. In terms of demand, we look for people in actuary, data analytics, IT, operations, sales, marketing, and more. From the traditional disciplinary areas, with the exception of actuaries [where we see short supplies], we are fine with the caliber of students that are coming out of colleges. Regarding technical expertise, I think there is no shortage of that coming out of universities. However, when it comes to **resilience, teamwork, and even communication skills,** there is room for improvement.

Jutta Williams - We hire these young and brilliant data scientists; we train them well on technical skills. But when they apply the knowledge at work, in many areas including healthcare, they have not yet learned the emotional intelligence necessary to apply data in ethical ways to solve problems. Ethics is a set of skills that can be learned; **ethical skills** can be learned in a classroom, and there can be logic tests, until the time that you can actually apply them emotionally in real-time as empathy. I believe that we do not do enough work on developing **emotional intelligence** at younger ages.

In health care, we have such a diverse set of people who touch data and information. Based on some work I did in DC, on the average, 222 different people in the healthcare system are involved, per person staying in the hospital for three days. So that's how many career pathways are required in touching health data in order for one person to receive care from the emergency room until they are discharged home in 3 days. How you create an ethical understanding of the use of data across those 222 types of people is incredibly hard to scale.

And then when you look at the educational pathway for a lot of those jobs, it is concerning. We need people so badly that we are reducing the level of education to the very technical minimums necessary for them to do the job, because we are trying to force people into the workforce faster to cover the skills gaps.

Randy Iwasaki - Changes in technology are very important and students having the **technical skills** to enter the workforce is important. But also, **teamwork** is very important. You always have to work with others in industry, so it is important that you learn the skill in university.

John Litzinger - I like the idea of spiral development in education. You have a bit of that kind of experience with the senior projects. But in today's world, that is not enough. What if students were offered the opportunity to do projects through their studies, not just in the last year?

New graduates are really good at getting their task done, solving their particular problems. That is what they are learning through undergrad education. But when it comes to **teamwork,** they lack the necessary skills. Being able to work well in a team and asking yourself what is the value that I bring here, helps advance the team and organizations goals, as well as your career.

Yassi Moghaddam - To build on that point, I think being **solution-oriented** is a mindset that can be taught at school. That is looking at problems with a commitment to solve, rather than to avoid. That is part of having a Growth Mindset (Dweck, 2006) that should be taught way before college, but higher education is also a good place to be given the opportunity to learn this skill.

I also think that the issue of solving our skills gap is a lot more complex than just turning the higher education system into a factory that teaches students only job-relevant technical skills to turn them into workers quickly. Before we learn to be a good worker, we must learn to be a good citizen, something that is especially critical in the age of AI. Helping students connect the two has historically been the mission of higher education institutions and integrating Liberal Art and Humanities topics into the STEM curricula has been one way they have fulfilled this mission. Going into the future, it is even more incumbent on higher education institutions to enhance, not diminish that integration.

Question from Roshy Mozafar, Environmental Eng. Consultant, Kane Environmental Inc (participant) - You brought up a point about people participating and helping out with other teams, if needed, to get the project done. From an employee's standpoint, it is important that the employer creates an environment that encourages that kind of participation for people to take risks and participate in activities in which they are not necessarily experts. A lot of new employees are afraid to take those risks because they think their jobs might be at stake if they make a mistake.

Jutta Williams - I think it goes even way back further in their lives. Learning the skill of **how to fail well** is very important. Today everything is a permanent record. So, we have a very risk-averse population coming out of school and it is getting more and more extreme.

America is the land of innovation, the land of the idea factory. If we have one product that we export to the world, it is ideas; and ideas come from innovative thinking, taking risks, not following rules. Today, there is so much aversion to risk - to stretching beyond what we know, and what we are capable of, for the fear of not getting the A.

I do a lot of college recruiting, and **risk-taking skills** are so incredibly rare in these young folks. At Facebook, we look for those graduates who know how to take risks and how to fail well.

Yassi Moghaddam, Q 3 - The last question for the panel, when you think of undergraduate education in the U.S., what is the one word that comes to your mind when you think of a strength, and one word when you think of a weakness.

John Litzinger - Communication is weak; technical is strong.

Randy Iwasaki - Technically strong; interpersonal acumen weak.

Jutta Williams - Technically very strong; weakness is fear, students come out afraid.

Nate Tymann - Open-minded is a strength; overconfidence is a weakness.

6.3.3 Panel 3 – Perspectives from Education

Moderator: Jim Spohrer, Director, Cognitive OpenTech, IBM, ISSIP Board Member

Panel speakers:

- **Elaine Collins, Associate Dean, San Jose State University, (perspectives on a partnership with Braven[8])**
- **Mark Hudson, Academia Manager, and Erin Smith, Senior Territory Brand Manager, Axelos**
- **Layla Sabourian, CEO, Chef Koochooloo**
- **Justin Sewell, Director of Programs and Partnerships at Krause Center for Innovation**

Summary of Panel 3 - The speakers in this panel represented views from several innovative education organizations that are leveraging successful partnerships to fill the skills gap between 4-year academic education and employment. This panel pointed out how higher education can better partner with industry to ensure the relevance of academic content to industry and to foster job-relevant experiential learning through well-structured apprenticeship and internship programs. Pioneering industry-education collaboration models come in different forms. Some universities and community colleges are partnering with new learning organizations and local businesses to bring experiential and career-enhancing learning to students. Other universities are partnering with educational startups to provide career pathways to STEM jobs for underserved student populations. Also, innovative service organizations are offering the content of their high-demand industry certifications to universities for integration into academic curricula in order to develop rapid micro-learning capabilities.

Jim Spohrer opened the panel by introducing each of panel speakers, and the organization and their novel initiative that they represented on the panel.

In this panel, we will hear from several speakers about innovative public-private partnership

[8] https://bebraven.org/ - accessed Feb 2, 2020

educational initiatives. Elaine Collins is an Associate Dean of School of Science, at San José State University (SJSU), but today she is representing BeBraven.org, an innovative education startup, which has had a partnership with SJSU for several years. Mark Hudson and Erin Smith are joining us from the UK, representing AXELOS, a public-private partnership in the UK that offers best practices for IT operation globally. Axelos is the provider of the ITIL framework[9] worldwide, and most recently they are taking their certifications to universities. Layla Sabourian is an entrepreneur. She is the Founder and CEO of Chef Koochooloo, another innovative education startup company that helps the next generation learn about STEAM (Science, Technology, Engineering, Art, and Math). Justin Sewell, Director of Partnership Programs, Krause Innovation Center (KIC) will tell us about KIC partnership with Foothill and De Anza College, two premier community colleges in Silicon Valley for associate degrees with fantastic programs for transitioning into Berkeley and other UC [University of California] systems.

Elaine Collins, Associate Dean, School of Science, SJSU: I am Associate Dean of the College of Science at San Jose State University. In early 2015, along with colleagues from Engineering School, and Business School, we started looking at the problem of how and why is it that some of our women students do not do as well as their male counterparts when they get into the job market, even though they are equally talented in the classroom. As we were exploring potential programs to kick-off a program to address this issue, we came across a nonprofit, Braven [BeBraven.org], which was then called Beyond Z[10] [based on the book by Dr. Seuss, Beyond Zebra[11]], which happened to be doing a pilot on our campus. They had developed a very high-quality online career and leadership development curriculum, targeted for underrepresented students. Since we liked what we saw, instead of reinventing the wheel, we decided to work with them, and eventually offered their program as a 13-week elective class.

The way that their model works is that they recruit young professionals from the Silicon Valley companies to work as leadership coaches for student-teams and to volunteer each week and meet with students to work on developing a story of self, how to build a resume, how to write a cover letter, and how to interview well. In the end, the students are given a project that the student teams work on together, using design thinking to address a business challenge. This year [2019], almost 200 students completed our class.

We met with Braven, for the first time, in March 2015 and we were able to offer the class for the first time in fall 2015. So, despite what we have heard about how slow academia can be, there are ways that you can get things done quickly, if you know how to work the system.

Mark Hudson, Academia Manager, Axelos[12] - AXELOS offers a range of certifications that are designed to help businesses become more productive across a range of key capabilities such as project management, programming, and IT service management. We offer two well-known certifications: one is PRINCE2 for project management, which is less well known in the US; and ITIL for IT service management, which is very well-known and widely used in the US. Through its partners, Axelos gives 400-450 thousand certifications annually worldwide. About

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[9] https://en.wikipedia.org/wiki/ITIL - accessed Feb 2, 2020

[10] http://www.beyond-z.com/index.html - accessed Feb 2, 2020

[11] https://en.wikipedia.org/wiki/On_Beyond_Zebra! - accessed Feb 2, 2020

[12] About AXELOS, see here: https://en.wikipedia.org/wiki/AXELOS, pulled Feb 24, 2020.

two years ago, we saw an opportunity to provide our certifications to university students [for digital readiness upon graduation]. We have been working with universities to embed our certifications within their courses. We are currently working with a vast and wide list of institutions, with quite a few in the USA. What we are seeing in the U.S., but also in institutions in Australia, EMEA (Europe, the Middle East, Africa), UK, is almost like a perfect storm where you have on the one hand employers who have this need and are expecting graduates to be more work-ready, and at the same time, they are expecting a high level of soft skills. These are "transferable skills." According to a study conducted by the city of London, Nesta, the top 6 transferable skills rated by employers are: 1) oral communication; 2) collaboration and teamwork, 3) initiative; 4) problem solving; 5) organizational skills; and 6) adaptability.

Erin Smith, Sr. Territory Brand Manager, Axelos - From and industry demand perspective, there is a need for education to be working at a quicker rate than it currently is. But, higher education is bogged down, sometimes, for a number of very legitimate constraints. And so the purpose of AXELOS partnering with academia is to work with academia to move quicker with digital innovation, given some of their constraints.

Layla Sabourian, CEO and Co-Founder, Chef Koochooloo - "Koochooloo" means 'the little one" in Farsi, Turkish, Italian, and a few other languages. My background was in marketing enterprise software and I stumbled into what I am doing watching my daughter attend school. She once asked me: "Mom, why is it that boys are so much better at computers than us?" That prompted me to start examining why that was the case. I looked at some of the educational games, and, lo and behold, the majority of games are created by 20-30-year-old males. That prompted me to some research that led me to design a game, which consists of a curriculum to teach students math through healthy cooking. I first taught these to schools and teachers, as a volunteer. Then, one day a teacher suggested that the program is a great fit for NGSS [next generation science standards]. And, with the support schools and educators who believed in our interdisciplinary approach, we applied for a grant from the National Science Foundation which we obtained more than three years ago. We help teachers teach STEAM through the joy of cooking. STEAM is STEM, but it is adding in applied "arts" and creativity. Today we call STEM a modern approach, but let us remember Leonardo da Vinci was a scientist who did study engineering and then picked up art.

Justin Sewell, Director, Krause Innovation Center (KIC) - Having been a teacher before joining the Krauss center, I have a perspective on what education looks like from bottom to top, from elementary and middle school to community college.

Krause Center has been around since the year 2000. We provide professional development for educators to integrate technology into classrooms, and to engage students in STEM and STEAM in better ways. Over 21,000 educators in California have gone through our programs. Krause Center is associated with the Foothill-De Anza College District[13]. Our role is to help students transition from associate degrees to the workforce, either directly, or by first transitioning to a four-year university where they can eventually get a degree and then transition into a job. About 35% of all students who come from California high schools eventually end up at a community college. So, if you can think about how many students are coming through the community college system, it is an incredible number. KCI created certificates to help educators' professional development. We also offer the only Makerspace

[13] Two Premier community colleges in Northern California, http://www.fhda.edu/.

certificate in the state of California. Students or paraprofessionals from schools can come into our program. They receive Foothill college credits and then they also get the applicable skills to be able to manage and operate a Makerspace or tools in Makerspaces. Our training also focuses less on theory and more on applications. For Instance, we offer a quarter credit for Adobe Illustrator, or for design thinking. These courses are very affordable[14], making it more accessible to underserved students.

We also offer something called middle college which is a program for dual enrollment for high school students. They are high school students, but effectively are getting a college education.

Jim Spohrer, Q2 - In the context of thinking about reconstructing the current education system, I'd like to hear from all of you, what is the scale of your program? How many students do you help every year in this transition? What do you think are your biggest successes? And, what are some of the failures?

Elaine Collins - Our program started with 56 students a semester. Currently, it is serving close to 200 students a semester. We would like to get to 500 students a year. San Jose State has almost 40,000 students. Obviously, we're not touching everybody. But, we target underrepresented first-generation [immigrant] students. One of our biggest success stories is that we had a student that went to local high school, and then transferred from De Anza Community College to San Jose State. In his transfer orientation, our class was recommended to him. He signed up for the class and it, above everything else, gave him a sense of community; and then through the mentorship, he applied to the Google BOLD[15] program making him one of the first interns being accepted from San Jose State to the program. Then after he graduated, he was hired by Google. Before participating in our program, he could not even have imagined that. Another student went through the class and was later hired by Braven.

On the areas for improvement**,** the reason that we are able to offer this program with Braven and not with our own faculty is that we would not have the ability to train and recruit the local industry contacts. Also, San Jose State has been somewhat slow to take full advantage of our enrollment pool. A lot of leadership coaches, probably over half, are from San Jose State.

Mark Hudson - We generally run at about 450,000 certifications a year globally, the majority in the US, followed by the UK, and then other countries. While our industry program is well-established, our academic program is fairly new, so I do not have the exact numbers for student certification. We are getting various types of higher education institutions accredited, so college and university students can take our certification to better prepare them for the world of work. About 80-85% of those taking our certification exam pass, although those numbers vary by country.

Regarding our newly launched university collaborations: 2 US universities have included ITIL as part a core ITSM module for their undergraduate degrees; 1 Australian university offers AgileSHIFT as an elective component of its MBA program; 6 universities/colleges (2 US, 1 Canada, 2 Europe, 1 Australia) are currently in the application/accreditation process to provide

[15] https://careers.google.com/programs/bold/, pulled March 12, 2020

AXELOS certifications to their students and/or staff; and AXELOS collaborations are in discussions with many more.

Erin Smith - First of all, I think that higher education is still a great bedrock, and university education has its value. The area that I see has the most opportunities for improvement is in the return on student's investment (ROI). In the past, the four-year degree represented the way in which you moved forward on your career ladder. Today, the career ladder is much more now like a climbing wall where you have to be able to pivot and move from one role or industry to another. Being able to offer high-demand industry certifications to college students helps them with employability, and helps universities justify the ROI.

Layla Sabourian - So far, we have trained teachers in 30 schools and 9000 students, primarily in Silicon Valley, and Santiago, Chile. My favorite success story, we took a survey with 1000 parents whose children participated in our program. One hundred percent of respondents had said their child hated math and science before participating in our program. And then after 10 lessons, all the students wanted to be scientists or engineers. So that was a huge impact. Another success story, a student came to my class and the first day said: "I just want to let you know, I hate being here, my mom forced me here. I don't want to eat vegetables and I hate math." So, I said: "Ok, you just sit and observe." And now, he wants to become a chef.

I think one major problem with STEM is that most [middle school, high school] teachers in math, in science and engineering, lack the passion for these subjects themselves, and that cascades into students. I would solve that problem by making it a requirement for those seeking master's degrees in science and engineering to spend one semester in an economically disadvantaged school teaching science or math. This is different from "Teach For America," which targets those who have graduated from a 4-year program, but not necessarily from STEM.

Justin Sewell - Educators operate in their comfort zone and are typically averse to implementing technology into their classrooms. As far as success, we serve hundreds of educators each year in a variety of our programs, which translates to thousands of students. To get educators out of their comfort zone, using design thinking, we designed our program around four pillars of computational thinking, i.e., algorithms, patterns, decomposition, and abstraction, which we introduce in the context of their everyday work. That approach of meeting educators where they are is the reason for the success of our program.

As far as areas for improvement, I believe community colleges today are underutilized, because, today, they offer a subset of the same classes you get at four-year institutions for much lower costs. A better model would be for community colleges to focus on offering 2-year intensive programs focused on job-preparation in STEM-related fields. A good playbook for this is "42 Silicon Valley[16]", which is a school [not a community college], based in Fremont, California, where students who are interested in computer science go for two years. They offer an intensive tuition-free program with a very holistic and practical approach to learning computer science to prepare students for the workplace.

[16] About "42 Silicon Valley", https://www.42.us.org/, pulled Feb 24, 2020.

Jim Spohrer (About IBM P-Tech Program) - The IBM Pathways in Technology Early College High Schools (P-TECH)[17] are innovative public schools, grades 9 to 14, that bring together the best elements of high school, college, and career. The program has been around for about a decade, and President Obama mentioned it in one of his State of the Union Addresses. It is a program that tries to address some of the issues that high school students have, especially those underrepresented in the workplace. The program is a public-private partnership that is designed to be replicated around the world, and it is still scaling up. Today, there are 200 P-TECH schools with more than 100,000 students in 18 countries.

To set up a P-TECH, you have to have a high school, a community college or university system, and a network of local employers, because there is a contract that gets signed with students saying if you learn this material, you will have a job every summer. And in two years, after they graduate, most of the students get a job, very often with the employer where they had their internships. The success of a P-TECH requires that industry step up and hire these interns and students, and it also requires that the high school teachers partner with the university faculty (who are the experts in the skill that the industry wants to hire).

The program has been fairly successful. It has about 10% or 15% failure rate, and typically the students do not succeed in the contract for a variety of reasons, but majority of cases is unrelated to the student's ability and more related to the complexities of their personal and family life. We are also starting to see that graduates now come back as volunteer industry mentors.

P-TECH is usually set up around locations where IBM has a large facility, like Yorktown, New York, or Raleigh-Durham. They also recently started a P-TECH here in Silicon Valley. IBM set up the first five or six P-TECH, and now offers a playbook for any company that wants to set up a P-TECH.

Jutta Williams - In Colorado where I live, we started with a P-TECH that IBM sponsored just outside of Boulder, and my local high school has a P-TECH program. Incoming freshmen enroll or apply because there is a limited number of seats. It is intended specifically for disadvantaged students who lack a lot of opportunities and are probably not college-bound otherwise. And by the time they graduate high school, if they worked really hard, they are on their way to an Associate's Degree or may have even obtained their Associate's Degree in a related field, either MIS or CS. It is an amazing program. Another high school nearby recently started a P-TECH for health-related technologies. This one was sponsored by a healthcare company to prepare students for advanced healthcare IT skills.

Comment from Thomas Hollmann, Executive Director, Center for Services Leadership, Arizona State University - In Germany, where I grew up, we have a dual education apprenticeship model which works great for the kind of industries that we have in Germany. The model is that students are hired directly out of high school and on a 50% basis attend both school and work at the same time. This model is an example of an application of the "spiral development model" to education. In our traditional approach, we lock students away for four years and then toss them to work, without much preparation, as opposed to a more ongoing spiral approach where the student goes to the classroom, learns something, goes back to work, and applies the learning to work. I wonder how we might apply this in the US?

[17] P-TECH - https://www.ibm.com/thought-leadership/ptech/index.html

Rick Rafey - I want to pick up on that point about Germany and its successful apprenticeship model. What they do in Switzerland is also a good model (Maurer, 2018). Theirs is an applied model, somewhere between a community college and "42 Silicon Valley". Anything that is a step toward an apprenticeship in the US is an improvement to the current system.

Regarding "42 Silicon Valley", we have hired a few of their graduates, and have been very impressed by the quality of the graduates. The people certainly have applicable skills. It is very rigorous and experiential, and students work in group projects. But the program is not as theoretical as a university program. Graduates are not ready to do architecture for a Google algorithm, but they can absolutely write very interesting code with enthusiasm and **lots of initiative** which is another important skill.

6.4 Breakout Session

To explore in more depth industry perspectives on challenges and opportunities faced by higher education institutions for workforce upskilling and reskilling, the workshop participants were asked to form four breakout groups. Each group was to perform its own SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis of today's US 4-year higher education systems and institutions. After 1 hour, the groups reported out to each other. A combined view across the four groups for each of the SWOT components is presented below:

6.4.1 Group 1 SWOT Analysis:

Strengths • Creative thinking • Anyone can access education • Theoretical Focus/ Ability to bring tech to classrooms • Social engagement/ out of class interactions • Writing/speaking/ communication skills	Weaknesses • Lack of diversity • Education as an elite concept • Disconnected from workforce expectations • Standardizations has led to meeting a very minimum bar • Lack of connection to industry • Mentally unhealthy graduates • Cost • Class sizes too big, attention to students too little
Opportunities • Project based/ problem-based learning • Competencies vs. time in class • Technology access for all • Credentialing programs • Lifelong learning opportunities • Making higher education a part of every student's educational	Threats • Cost • Potential for irrelevancy • Consumerization of education

experience • Micro courses	

6.4.2 Group 2 SWOT Analysis:

Strengths	Weaknesses
• Tech skills • There is a quality control for university system • Opens minds • Culture of college-social growth • Promotes writing, speaking, presentation skills	• Professor do not value the work of educating over research • High costs to students (tuition, fees, books, and room and board) • Soft skills not taught sufficiently • College party culture • Ethnic/gender equality (racial/cultural/socioeconomic) • Sensing needs of industry • Inability to support mental health • Not having enough alumni and industry mentoring programs • Big/Huge classes (not enough attention to students)
Opportunities	Threats
• Project/Problem solving • Financial gain for students • Increase potential for professional growth • Study abroad/exposure to other cultures • Low income populations to get out of poverty • Build bridges to industry • Collaboration with other organizations	• Certificate / badging programs • Becoming irrelevant outdate • Cost / Regulations • Online courses • Pipeline of new faculty

6.4.3 Group 3 SWOT Analysis:

Strengths • Discipline knowledge • Institution already there • Research US specially • University community broadening • Liberal arts and general education • Build a network with classmates and professors • Building a citizen	Weaknesses • Agile teaming • Applied learning (“pockets”) • Industry production model and metrics • Slow change sometimes • Silos both universities and industry • Balance (tech, humanities for example Sweden)
Opportunities • Industry/cultural insertion program • Build bridge/path between University and industry, for example Google-Stanford • Free education like other countries • Forgive debts • Build Service science capabilities • Sandbox partnerships around new technologies • Completion rate increase (Ca 800k)	Threats • Online programs threat to existing institutions • No moral high ground - demise of academic freedom • Automation

6.4.4 Group 4 SWOT Analysis:

Strengths • Variety of university and colleges • Flexibility • Standardization/structure • Scientific community/networks • College experience • Specialization	Weaknesses • Incentive for faculty at odds (with what is expected from industry) • Lack of applied experience • Slow to change • Risk-averse cultures • Large class sizes • Teaching soft skills • Taxonomy of new skills • Misaligned with industry skills
Opportunities • Teaching ethics and values • Micro- foundations • Apprenticeships • Undergraduate research collaborations • New jobs/ New data • Industrial PhD • Experiential education • Develop or recognize young thinkers/ scientist under 30 • Flexibility in grading (e.g. pass/ fail) • Interdisciplinary studies • Industry – University journals	Threats • Obsolescence of current education discipline or structure • Loss of old jobs • Old data used that is obsolete • Adaptability to sectors • Culture bias to dystopia

Combined Recommendations from the four SWOT analyses cluster into institutional incentives, curriculum changes, enrichment experiences, inclusion, partnerships, and lifelong learning.

<u>Institutional Incentives</u>

- Include relationships with industry (quality and quantity) as a measure in faculty performance.
- Build a balanced-scorecard for education, with multiple matrices, which should reflect objectives beyond courses and grades.

<u>Curriculum</u>

- Revise curriculum to meet industry needs - build advisory boards from industry to evaluate curriculum relevance to industry. Eliminate old courses/add new ones to keep pace with industry needs.
- Encourage interdisciplinary learning - deindustrialize the education system, students should be able to figure out different ways to solve a problem, rather than just a transfer of knowledge.

- Tailor evaluations to the individual. Learning should be kept flexible to cater to different kinds of students.
- Emphasize applied real word problems that break silos (sandbox).
- Offer applied learning and develop case studies.

Enrichment Experiences

- Provide more learning opportunities for project-based learning starting from freshman year.
- Provide opportunities for apprenticeship programs, co-op education, internship programs to provide experiential learning and assist with expenses
- Engage the alumni network beyond fundraising.
- Offer speaker series by industry leaders (with diversity and inclusion in mind), especially to inform career pathways.
- Create a "sandbox" for long-term 5G apps creation by students, as an industry-oriented project-based learning platform, using multi-vendor IP open source.

Inclusion

- Be intentional for making programs accessible to underrepresented groups.
- Gather and widely disseminate information on student aid.
- Find various ways to relieve the pain of student loans. Consider debt forgiveness in exchange for work commitment/teaching after graduation.
- Tap into the natural strengths of young talent.

Partnerships

- Build partnerships with high schools and community colleges to support life-long learning.
- Revisit partnerships with industry - lifelong learning and academic/workforce transformation.

Lifelong Learning

- Foster lifelong learning – consider a "once a student always a student" program.
- Alumni should be able to avail from past credits.
- Establish university programs for lifelong learning certificates for citizens.

6.5 Workshop Closing Remarks

Yassi Moghaddam - Our purpose for today's Workshop was to provide higher education leaders with an industry perspective on STEM education for the future, aiming to close the gap between undergraduate education and employment that would lead to a thriving 21st century workforce in our nation.

ISSIP catalyzes industry-academia-government collaboration in cutting edge research, best industry practices, innovative educational models, and policies that promote advancement of innovation and smart service ecosystems. So, we are happy to partner with everyone here to recommend industry perspectives aiming to close the gap between undergraduate education and employment that would lead to a thriving 21st century workforce in our nation.

In recap of the day, highlights included:

- Two categories of skills
    - Panel speakers and participants identified a number of important skills as required for new jobs of today and tomorrow. These skills were viewed in the Workshop as belonging to two major categories:
        1. Specialized Skills - those technical and scientific skills for which requirements keep changing as technologies advance and require rapid reskilling (e.g., computer science, data science, AI, IoT, cloud computing, and more).
        2. Foundational Skills - those skills that lasts over a lifespan of a career, and are transferable across technologies, jobs, companies, and even industries (e.g., abstract thinking, communication, leadership, self-awareness, teamwork, systems thinking, value orientation, entrepreneurship, critical thinking, analytical thinking, probabilistic thinking, open source community building, and more). The long-lasting nature of Foundational skills that require more time to learn lends itself better to transitional modes of higher education.
    - The majority of the workshop participants believe that the US universities are stronger in teaching Specialized Skills than in teaching Foundational Skills.
    - Data and analytical skills are considered by the workshop participants as both Specialized Skills, and Foundational Skills. While a deep level of expertise is required for data scientists and AI experts, a basic level is required across STEM jobs even for non-STEM graduates.
- Multi-mode and cross-disciplinary curriculum and instruction
    - The constantly changing nature of Specialized Skills offers opportunities new micro-learning mode of education (a capability that is inherently difficult for universities to develop) to facilitate rapid reskilling.
    - Panelists and participants recommend higher STEM educators de-emphasize subjects with less relevance to industry to create room for subjects that are more relevant.
    - Industry participants invite collaboration with industry to assess curriculum relevancy.
    - Workshop participants encourage higher ed STEM programs to partner with industry, as well as community colleges, and even high schools, to scale micro-learning programs designed for specialized skills, especially for micro-learning opportunities.
- Widening Gap Between Expectations and Results - The democratization of information raises the bar for the traditional academics, as knowledge from top scholars is available free or at costs far lower than many higher education degree programs. The perceived lack of relevance in traditional higher education disciplines and structures has contributed to an eroded confidence in the 4-year STEM degree as the pathway to high

paying jobs and has widened the perceived gap between expectations for 4-year STEM degrees and confidence in their ability to fulfill those demands.

- Life-long and Interdisciplinary Perspectives - Higher education leaders, according to the panelists, could consider re-focusing the 4-year STEM degree programs on providing learning opportunities for the broad Foundational Skills that prepare the learner for life-long learning.
    - Universities/colleges can improve on providing learning opportunities for developing interdisciplinary skills (considered foundational in the Workshop), since applications of computer science, data science, AI, IoT into various industry sectors are the keys to driving innovation.
    - It would be a mistake for higher education to focus on STEM education at the exclusion of liberal arts and humanities; liberal arts perspectives are especially important in the age of automation; and AI and must be integrated into STEM curricula.
    - Both STEM and non-STEM students should have access to learning opportunities that prepare for STEM jobs of the future.
    - To be more effective, innovations in educational curricula must become retroactive to K-12.
- Finally, Survey results to date and Workshop results are consistent.

Concluding Remarks and Future Directions

This report summarizes the outcome of an NSF-sponsored project entitled “An Industry Perspective on STEM Education for the Future: Workshop.” The outcome includes the results of the Workshop, held on Dec 10, 2019, Santa Clara, CA, the results of the stakeholder feedback Survey taken by 75 experts representing diverse industry sectors and 20 subsequent stakeholder Dialogues.

Figure 1, presented in the Executive Summary of this report, encapsulates an industry perspective for skills development for new jobs of today and tomorrow, developed by the authors of this report based on the research results from the Workshop, Surveys and Stakeholder Dialogues discussed above. The figure shows two broad categories: Specialized Skills, those that require deep knowledge, but for which requirements continually change as technologies advance; and Foundational Skills, those that are long-lasting and transferable across technologies, jobs, companies, and even industries. Acquiring Specialized Skills for the STEM jobs of the future has been the focus of most STEM higher education programs to date, and this is a strength. However, to be sufficiently prepared for the jobs of the future, STEM graduates must come into the workforce also prepared with the Foundational Skills that enable them to adapt quickly to the constantly changing environment of work.

STEM job opportunities today, and for the foreseeable future, stem from many fields of science, technology, engineering and math – with applications in artificial intelligence, cybersecurity, cloud computing, data science, IoT (Internet-of-Things), open-source, and blockchain. New jobs are emerging in quantum computing, biomedical, control systems, robotics, telerobotics, augmented reality, and virtual reality. Specialized Skills required for these jobs are constantly changing as technologies continue to advance. Therefore, a micro-learning mode for rapidly developing fields can better facilitate rapid learning and reskilling. Because of this, industry leaders encourage educators to consider re-focusing 4-year STEM degree programs more concretely on providing the broad Foundational Skills that transfer across jobs and prepare the learner for micro-learning throughout a lifetime.

Industry leaders believe that although the majority of high paying jobs will be in STEM, not every person who is hired into a STEM job will need to be a STEM graduate. Indeed, the leaders of American higher education are advised to evaluate and rapidly implement programmatic initiatives that will prepare both STEM and non-STEM students for the new STEM and STEM-aligned jobs. Some are of the opinion that liberal arts graduates with “digital skills” training will be in higher demand, particularly as AI becomes more pervasive in the workplace (Hartley, 2017).

Furthermore, while STEM graduates come to work fairly well-prepared with Specialized Skills, based on the results of the Workshop and Stakeholder Feedback, they often lack the Foundational Skills necessary to perform well in those jobs. Many of the Foundational Skills such as abstract thinking, conceptual problem solving, human-centered design, and creativity can be fostered by a well-integrated liberal arts education into STEM undergraduate programs.

There is an urgent need, according to the workshop participants, for the 4- and 2-year degree programs to better partner with industry to foster industry-relevant experiential learning

through structured apprenticeship, internship, and mentorship programs. Many examples of such programs presently exist, and a few were discussed during the Workshop. Some universities and community colleges are partnering with novel learning organizations and local businesses to bring career enhancing experiential learning to students. Other educational institutions are partnering with innovative startups to provide career pathways to STEM jobs for underserved student populations. Finally, companies are offering high-demand industry certifications to universities for integration into existing curricula; some skills verifications are offered in partnership with higher education STEM programs.

The US higher education system is recognized as “the best in the world” (The Economist, 2018). Key strengths of US higher education lie in the high educational quality standards and the diversity of degree programs for learning and research including STEM, Liberal Arts, and other a broad array of academic and professional expertise. In addition, the US higher educational system often operates in an environment that allows the learner to build social and cultural networks beyond the classroom walls.

The weaknesses of the of the American higher education ecosystem include high costs borne by students that makes access challenging to many Americans. Also, US higher education now reflects an imbalance of American vs. international graduates, a disconnect from industry expectations and its skills requirements for workforce development, and a risk-averse culture, combined with siloed administrative structures resulting in a slow pace of change.

Opportunities for higher education lie in expanding connection points to industry including internships/co-ops, apprenticeships, project-based/problem-based experiential learning in partnership with industry and even with other educational institutions, and providing lifelong learning opportunities, so students become “customers'' for life, not just for the first 4-years before the Baccalaureate Degree.

The threats include new learning organizations emerging in the ecosystem as well as obsolescence of current curriculum. The democratization of information raises the bar for the traditional academics, as knowledge from top scholars is available free or at costs far lower than many higher education degree programs. In addition, the perceived lack of relevance in traditional higher education disciplines and structures has contributed to an eroded confidence in the 4-year STEM degree, as the pathway to high paying jobs and has widened the perceived gap between expectations for 4-year STEM degrees and confidence in their ability to fulfill those demands.

Recommendations:
The following is a summary of this study’s industry leaders’ recommendations for strengthening the value of STEM higher education to American industry, based on perspectives gathered in this project:

1. Continue to build on the strengths inherent in the diversity and flexibility of degree programs for learning and research that span both STEM and Liberal Arts.
2. Strengthen the 4-year STEM curricula by emphasizing Foundational Skills and offering micro-learning programs for Specialized Skills through either in-house programs and/or through partnerships with other institutions such as community colleges and industry partners.

3. Encourage and incentivize faculty to grow connection points with industry in order to offer students job relevant experiential learning opportunities through initiatives such as industry projects, undergraduate research, industry guest lecturing, industry mentorship, and industry informational sessions about industry career pathways.
4. Given the fast pace of change technological change, review curricula periodically and in collaboration with industry advisory boards, considering the integrated industry perspective shown in Figure 1.
5. Expand curricula to enhance alignment of content to industry applications (vs. content focused on pure theory). For example, consider curricula with lighter emphasis on traditional theoretical mathematics and heavier emphasis on data science, probability and statistics.
6. Increase student opportunities for applied learning through apprenticeship programs, Co-Ops, and paid internships, as well as applied undergraduate research.
7. Promote connections between liberal arts/humanities and STEM learning in two ways: 1) emphasize the importance of liberal arts/humanities and their integration into STEM coursework and experiential learning; and 2) integrate digital literacy content into liberal arts curricula for enhanced relevancy to future STEM supportive industries and jobs.
8. Offer project-based learning opportunities throughout the undergraduate program (not limited to "senior projects" only).
9. Foster lifelong learning. For example, provide incentives for alumni to stay involved with higher education through guest lecturing, mentorship and professional education.

By providing this industry perspective on needs and opportunities to better align higher education and entry-level STEM workforce employment, this research has aimed to inform leaders of the US higher education of the changes in educational programs that industry requests in order to prepare the American workforce for new high-paying jobs and increase the innovation capacity in the US.

Future research:
During the course of this study, the project team identified several issues that require further investigation in order to fully inform higher education leaders on the preparation required for STEM jobs of the future. How are industry recruiters and hiring managers screening STEM graduates for Specialized, Foundational Skills? And how do those criteria and processes map into academic curricula? Further research could provide valuable guidance for educational institutions.

It is also important to note that this research was conducted before the COVID-19 crisis hit the US. As a result of the crisis, many aspects of work and learning is changing. To study the long-term impact of COVID-19 to work and learning, ISSIP has formed a Working Group (http://www.issip.org/about-issip/community/covid-19-working-group/).

Recommendation: NSF fund a follow-on study to go back to the Expert Panel and stakeholders surveyed to ask their perspectives on the long-term impact of COVID-19 on the requirements for and availability of future of skills. Please see Appendix L.

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Appendix A - Workshop Agenda

Tuesday, Dec 10, 2019

8:30-9:00	Check-in, breakfast, and networking
9:00-9:10	Welcome – Introduction, and Goal of the Workshop by co-chairs: Yassi Moghaddam - ISSIP Executive Director Stephen Kwan, Professor Emeritus, San Jose State University (SJSU) Lou Freund, Professor Emeritus, SJSU Martha Russell, Stanford University
9:10-9:30	Context from National Science Foundation, Dr. John Jackman, NSF
9:30 - 10:45	Panel 1 – Perspective from IT, Media and Entertainment, Telecom, Financial Services– Moderator: Susan Cantrell, Talent and Technology Strategy, Innovation & Thought Leadership (previously, Accenture & Johnson & Johnson) Panel speakers: • Naguib Attia, VP Global University Programs, IBM (IT, Professional Services) • Nitin Badjatia, Head, Product Strategy, ServiceNow (IT) • Guy Berger, Principal Economist, LinkedIn (Internet) • Yun Freund, Sr. VP Engineering, Equinix (Internet) • Alka Roy, Product and Technology Leader, AT&T (Telecom, Media & Entertainment) • Guru Sethupathy, Head of People Strategy & Analytics, Capital One (Financial Services)
10:45- 11:00	Break
11:00- 11:30	Overview of Industry Survey Results To-date - Dr. Stephen Kwan

11:30-12:30	Panel 2 – Perspectives from Healthcare, Health Insurance, Infrastructure, Transportation - Moderator: Yassi Moghaddam Panel speakers: • Nate Tymann, Director HR, BlueCross, Blue Shields (Healthcare, Insurance) • Jutta Williams, AI Senior Program Manager, Facebook • Randy Iwasaki, Executive Director, Contra Costa Transportation Authority (Government, Transportation) • John Litzinger, Associate VP, Group Director, HNTB (Infrastructure, and Transportation)
12:30- 1:30	Working Lunch - Participants Grab Lunch, Bird-of-the-Feather discussions
1:30– 2:30	Panel 3 – Perspectives from Education - Moderator Jim Spohrer, IBM Panel speakers: • Elaine Collins, Associate Dean, San Jose State University, (perspectives on a partnership with BeBraven.org) • Mark Hudson, and Erin Smith, Axelos • Layla Sabourian, CEO, Chefkoochooloo • Justin Sewell, Director of Programs and Partnerships at Krause Center for Innovation
2:30- 3:30	Breakout sessions, (moderators will be assigned during the Workshop)
3:30- 3:45	Break
3:45-4:45	Readout from Breakout sessions, group moderators
4:45 - 5:00	Closing remark and wrap up, Yassi Moghaddam

Appendix B. Workshop Attendees & Expert Panel Members

Workshop Participants		Company	Title	Vertical	Member of the Expert Panel
First name	Last name				
Naguib	Attia	IBM	VP, Global University Programs	ICT	Yes
Nitin	Badaja	ServiceNow	Head, Product Strategy - Customer Service	ICT	Yes
Divisha	Bera	SJSU	Student		No
Guy	Berger	LinkedIn	Principle Economist	Employment-oriented Digital services	Yes
Susan	Cantrell	Accenture	Innovation and Research Lead, Talent & Tech Strategy	Professional Services	Yes
Elaine	Collins	SJSU, representing Be Braven (an industry-university partnership for skills development)	Associate Dean, School of Science	Education	Yes
Yvonne	French	Cisco	Director, Talent & Workforce Planning,	ICT	Yes
Lou	Freund	San Jose State University (SJSU)	Professor Emeritus, Award, CO-PI	Education	No
Yun	Freund	Equinix	Senior Vice President, Platform & Products	ICT	Yes
Thomas	Hollman	Arizona State University, Center for Services Leadership	Executive Director	Education	No
Mark	Hudson	Axelos	Academia Manager	Education	Yes

				(corporate)	
Randy	Iwasaki	Contra Costa Transportation	Executive Director	Government & Transportation	Yes
John	Jackman	NSF		Government	No
Ann	Kalinowski	SJSU	Lecturer	Education	No
Stephen	Kwan	SJSU	Professor Emeritus, Award Senior Personnel	Education	No
Christopher	Lim	SJSU		Education	No
John	Litzinger	HNTB	Associate VP/Group Director	Transportation/Infrastructure	Yes
Alexandra	Medina-borja	NSF		Government	No
Yassi	Moghaddam	ISSIP	Executive Director	Non-profit	No
Roshy	Mozafar	Kane Environmental Inc	Environmental Eng. Consultant	Infrastructure	Yes
Mahsa	Nakhjiri	Flex	Senior Director, CTO Office	Manufacturing	Yes
Shourya	Patni	SJSU	Student		No
Rick	Rafey	InOrbit Inc	Lead Product Strategy	Digital Services	Yes
Ammar	Rayes	Cisco	Distinguished Eng.	ICT	Yes
Mary Roth	Roth	IBM	Senior Manager and Global Head, Research-Driven Solutions	ICT	No
Alka	Roy	AT&T	Product & Technology Leader	Telecommunication	Yes
Martha	Russell	Stanford University	Professor, Award Senior Personnel	Education	No
Layla	Sabourian	Chef Kochooloo		Education/Tech	Yes
Guru	Sethupathy	Capital One	Head of People Strategy & Analytics at Capital	Financial	Yes
Justin Sewell	Sewell	Krause Center for Innovation	Director of Programs and Partnerships	Education	Yes
Erin	Smith	Axelos	Sr Territory Brand Manager	Education (corporate)	Yes
Jim	Spohrer	IBM	Director, Cognitive	ICT	Yes

			Open Tech		
Pankaj	Srivastava	IBM	VP, Chief Analytics Office	ICT	Yes
Yosuke	Takashima	Japan Science and Technology Agency (JST)	Fellow	Government	No
Nate	Tymann	Blue Cross Blue Shield, NC	Director, HR	Healthcare	Yes
Ulf	Vinneras	Aruba Networks, (at the time of the workshop, Cisco)	Senior Director, Services	ICT	Yes
Jutta	William	Facebook	Sr. Technical Program Manager at Facebook AI	Media and Healthcare	Yes

Other members of the Expert Panel not Present at the Workshop:

First name	Last name	Company	Title	Vertical
PK	Agarwal	UCSC	Dean of UC Santa Cruz Extension	Education, and wide industry perspective
Rama	Akkiraju	IBM	Fellow	ICT
Rebecca	Campbell	Kings County	County Administrative Officer	Government & Agriculture
Haluk	Demirkan	University of Washington	Center for Business Analytics	Education with wide perspective into multiple industries
Terri	Griffith	Simon Fraser, formerly, Santa Clara University, and number of industry consulting	Keith Beedie Chair in Innovation and Entrepreneurship	Education with wide perspective into multiple industries
Jennifer Harrington	Harrington	Kaiser Permanente	Hospital Administrator	Healthcare
Alex Kass	Kass	Accenture	Fellow	Professional Services

Sunil	Kripalani	United Healthcare/Optum	Senior VP, Digital Transformation	Healthcare, Telecom
Elaine	Mason	Cisco	VP, People Planning, Design Analytics	Tech, telecom
Matt	Wendrof	VMware	Sr. Staffing Partner | University Relations Team | Office of the CTO	ICT
Heather	Yurko	Facebook	Director HR	Media

Appendix C - IRB Waiver Letter

SJSU SAN JOSÉ STATE UNIVERSITY
Office of Research
Division of
Academic Affairs
San José State University
One Washington Square
San José, CA 95192-0025
TEL: 408-924-2272
officeofresearch@sjsu.edu
sjsu.edu/research

9/16/2019

Dear Dr. Louis Freund,

This letter is to inform you that your IRB application for the study "An Industry Perspective on STEM Education for the Future" has been evaluated by the Office of Research.

We have determined that the activities described in your protocol do not constitute research involving human subjects and do not require IRB review under Section 1.2 of F17-1 SJSU Policy for the Protection of Human Subjects. Human subjects are involved when the research entails interaction or intervention with living individuals that solicits personal information or the collection of individually identifiable private information.

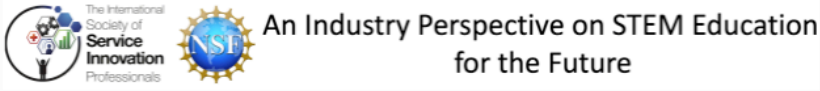
We appreciate your efforts in preparing a complete IRB protocol. Please be aware that an exclusion worksheet is available to help investigators determine whether their work meets the federal definition of human subject research. The worksheet is posted on the forms page of the IRB website: http://www.sjsu.edu/research/docs/irb-exclusion-worksheet.pdf

Investigators may use this worksheet to independently determine whether a protocol submission is required. If you have any questions, please do not hesitate to contact our office. I can be reached at Alena.Filip@sjsu.edu or 408-924-2479.

Sincerely,

Alena Filip
Human Protections Analyst
Institutional Review Board
Division of Research and Innovation
San Jose State University

Appendix D - Survey Instrument



Introduction

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Dear colleague,

Please take this brief survey to help influence improvements to the US undergraduate programs in the US to better prepare new college graduates for a thriving 21st-century workforce in our nation.

The survey is part of a National Science Foundation project undertaken by the International Society of Service Innovation Professionals (ISSIP, www.issip.org) to solicit and reflect on what industry deems necessary to better prepare students with skills required for future of work and jobs. The project will culminate in a report which will be made available to you.

Your participation in this survey is completely voluntary. Your personal information (including name, email, organization, etc.) will be kept completely confidential. No personal information will be shared in the reporting of the results or with any other individual or entity outside of the ISSIP Project Team. By completing this survey you give ISSIP permission to reflect your insights anonymously into the final report.

If you have any questions or concerns, please contact us at fow@issip.org.

Many thanks for your contribution to this important project!

ISSIP Project Team
Lou Freund, Stephen Kwan, Yassi Moghaddam, and Martha Russell

Section 1 - Please fill in your Information

1.1. First Name

1.2. Last Name

1.3. email

1.4. Industry Sector (from Global Industry Classification Standard - see details)

1.5. Organization

1.6. Department Name

1.7. Department Size (personnel)

1.8. Position

1.9. Number of direct reports

1.10. Number of years with current organization

Section 2 - Workforce

2.1.
Considering the new hires in your organization this year, how prepared are they in each of the following skills? Also please identify which are the top 5 most important skills in the list.

	Preparedness							Top 5 Skills
	Very poor						Very well	
Creativity	○	○	○	○	○	○	○	☐
Analytical Skills	○	○	○	○	○	○	○	☐
Design Skills	○	○	○	○	○	○	○	☐
Customer Service Skills	○	○	○	○	○	○	○	☐
Collaborativeness	○	○	○	○	○	○	○	☐
Computational Skills	○	○	○	○	○	○	○	☐
Forecasting	○	○	○	○	○	○	○	☐
Data Skills	○	○	○	○	○	○	○	☐
Cognitive Flexibility	○	○	○	○	○	○	○	☐
Leadership Skills	○	○	○	○	○	○	○	☐
Negotiation Skills	○	○	○	○	○	○	○	☐
People Management	○	○	○	○	○	○	○	☐
Judgement and Decision Making	○	○	○	○	○	○	○	☐

2.2. What ***other*** critical skills ***not listed above*** that are considered important and the new hires' preparedness in these skills?

	Critical Skills	Preparedness						
		Very poor						Very well
1		○	○	○	○	○	○	○
2		○	○	○	○	○	○	○
3		○	○	○	○	○	○	○
4		○	○	○	○	○	○	○
5		○	○	○	○	○	○	○

2.3. How do you think the skills, their importance, and new employees' preparedness will ***change 5 years from now***?

Section 2 - Workforce

3.1. Thinking about recent graduate hires in your organization, especially those going into a project/corporate management job or career path, what are your organization's expectations of skills?

3.2. How will these expectations of skills for new hires in a project/corporate management job or career path ***change 5 years from now***?

3.3. Thinking about new hires in your organization, especially those going in a strictly technical job or career path, what are your organization's expectations of skills? (emphasize differences from above)

3.4. How will these expectations of skills for new hires in a strictly technical job or career path ***change 5 years from now***?

Section 2 - Workforce

4.1. Are non-technical employees in your organization required to have programming/computing expertise?

	Yes	No
Required	○	○

4.2. What is the required degree of programming/computing skills and knowledge for non-technical employees in your organization?

	Very Limited						Expert
Skills and knowledge	○	○	○	○	○	○	○

4.3. Please specify required programming languages and computing environment for these non-technical employees.

5.1. What Tools or types of Tools are new technical hires expected to be able to use immediately after hiring and what tools your organization prefers to train new hires to use? (select multiple, leave blank if not applicable)

	New Hires Come Prepared	Your Organization Prefers to Train	Tool Brand Names (separate by commas)
Cognitive Assistant	☐	☐	
Presentation	☐	☐	
Project Management	☐	☐	
Virtual Reality	☐	☐	
Database	☐	☐	
Statistics	☐	☐	
Computer-Aided Design	☐	☐	
Programming Languages	☐	☐	
Spread Sheet	☐	☐	
Collaboration	☐	☐	
Math Programming	☐	☐	
Analytics	☐	☐	
Social Media Management	☐	☐	

5.2. What other Tools or types of Tools are new hires expected to be prepared to use prior to entering the job market and what tools does your organization prefer to train new hires to use?

	New Hires Come Prepared	Your Organization Prefers to Train	Tool Brand Names (separated by commas)
1	☐	☐	
2	☐	☐	
3	☐	☐	
4	☐	☐	
5	☐	☐	

6.1. How well does the academic credit and degree structure of higher education prepare students to work in your industry upon graduation?

	Not at all well						Very well
Preparing students to work	○	○	○	○	○	○	○

6.2. Please expand on your answer:

7.1.
When making hiring decisions, does your organization consider verificable skills certification/badging achievements of applicants as compliments to academic degrees?

- ○ Yes
- ○ No
- ○ Do not know

7.2. Please expand on successes, opportunities, and challenges, if applicable.

8.1. How important are the following for the workforce in your industry ***five years from now***?

	Not Important						Very Important
Life-long learning	○	○	○	○	○	○	○
Pervasive Learning (learning at the speed of need, through formal, informal, and social learning modalities)	○	○	○	○	○	○	○
Remote Working	○	○	○	○	○	○	○

9.1. Has your organization been able to access a sufficient number of US university bachelor's degree graduates from Science, Technology, Engineering, and Math (STEM) programs (e.g., BS Biology, BS Computer Science, BS Math, etc.) as job candidates over the past few years?

	Not adequate						Very adequate
Degree of sufficiency	○	○	○	○	○	○	○

9.2. Please expand on your answer:

10.1. Please provide any additional comments and questions about the workforce, your industry/organization requirement, and the road ahead ***in the next five years***.

10.2. Would you like to:

	Yes	No
Participate in a follow-up interview	○	○
Receive a copy of study report	○	○

Appendix E-K: Detailed Survey Responses

Appendix E: Detailed answers for Q 2.3 - How do you think the skills, their importance, and new employees' preparedness will change 5 years from now?

Line Number	How do you think the skills, their importance, and new employees' preparedness will change 5 years from now?
1	Technologies will continue to change rapidly. So, what we learned in school will get outdated soon. There has to be a lot of focus on continued education in the workplace. Employees have to be flexible and adaptable to learn new skills quickly to stay relevant.
2	Being able to adapt to new situations and challenges due to increasing pace of disruption.
3	I believe there's a great inversion happening. For all the focus on technical ability, the real shift over the next five years will be back to interpersonal skills. A.I., machine learning will offload most technical skills and future problem-solving will require the ability to collaborate across different personas
4	The workforce is going to become increasingly distributed, so the ability to be effective in these skills in remote roles, requiring autonomy and ability to collaborate from afar, will be more important. Also, AI and Machine Learning, falling under the umbrella of Data Science, will be on par with programming as key skill needs.
5	Cognitive and data science skills will be at the top
6	not sure
7	Due to fast pace of technology, the skill sets required will vary in the future.
8	There is more emphasis on Data Science, AI, Model Building. But domain, analysis and applicability of the data-- creativity, responsible leadership and judgement and ability to understand a domain but apply insights cross-domain will become more important.
9	The importance of communication skills will go up. Judgement and people skills combined with creativity and technical problem solving will be the key.
10	There are many occupations and roles that do not exist today and will be created in five years. Our educational system is not necessarily preparing students for what's to come and have a flexible mindset and be in constant learning pattern. Education should also focus on people's skills "upgrades" later in their career too. Moving to just-in-time on-the-job skills building will be critical.
11	Creativity and forecasting will be more critical since data/computational skills will become more automated. Judgement and decision making will be the hallmark growth skill we need to teach to young people.
12	Programming and knowledge of cloud technologies will become more important. Employees preparedness will improve on technical dimensions but ability to

	design client solutions will continue to be a challenging area for new hires.
13	complex problem solving will be ever more important
14	I think that the current generation Y is suffering from most of the skills above, because of theories in education such as No Child left behind, or too much focus on Only positive discipline, has created a generation that is impatient, has a false sense of confidence, and not prepared well for working in a competitive global setting. I believe both parents and employers are now able to clearly see the issues that this philosophy has caused, and now the trend is shifting to provide more criticism to children and more accurate feedback and prepare them better for the real world. Also, more emphasis on soft skills is being placed, so I believe in 5 years, we will be in a better place than we are now.
15	With proper mentor-ship I think the skills of new employees will grow tremendously in a positive direction for the benefit of the organization.
16	We are moving into a more agile world. With the pervasive advancement in technology, it is going to be imperative that employees adapt to the ever-changing landscape. We are moving at lightning speed and must have the self-confidence to adapt and challenge the status quo to be competitive in the workplace. This includes helping others around us adapt and thrive.
17	I think the skills will continue to evolve based upon the needs of the industries. There are jobs that exist today that didn't 10-15 years ago and with those new jobs, comes along a nuanced skill set required to do that work. In addition, how we learn today, absorb information and use information to complete our personal and professional work continues to evolve, thus a new employees' preparedness will have to morph to keep pace with the new environment.
18	I think the world is moving into the highly automated world and everything is involved with analytical, machine learning, and automation skills. Some of the existing candidates still have gaps in these areas.
19	Artificial intelligence
20	Cognitive flexibility, T-shapedness, Open Source will increase
21	Every senior leader is going to need a deeper understanding of software development and technology trends.
22	I believe that analytics and some of the decision making will continue to be automated and easier to pull data; the rest of the skills I believe will continue to be critical and perhaps even increase in value as "people skills" - things that will not be automated.
23	Increasing need for creativity, grasp of ethical behavior, ability to identify, react to, and repair unintended consequences of STEM innovation. Increasing need to understand the human aspects (inputs/outputs) of AI, ML, automation, increasing data pipeline.
24	I believe these skills will continue to be important 5 years from now. In some ways, the data (knowledge) accessible from the Internet is a hinderance. The civil engineering (Transportation) industry requires experience, trial and error, observation of others (projects and people), etc. to get good at it. There seems to be a belief that all solutions can be found out without much thought (just through a Google search (which is not 'research)).
25	IoT and AI needed along with network security
26	They'll need to have system development, networking, and improved software

	skills for sure. It will be critical to be able to understand a fully networked system approach.
27	I think we will see more AI and advanced complex systems. These need in depth knowledge and planning.
28	need more technology
29	Data Science skills may become more significant than, for example, people management, if the outreach methods and tools used to develop our standards change in that direction.
30	I think the employees are not ready for these changes. With automation and smart technologies, more employees need to collaborate with these technologies, but the current HR practices are not ready to hire, develop and retain these new digital employees.
31	More in tune with technology and doing things themselves vs. asking consultants to do it.
32	Adaptability related to augmentation of technology will continue to be important.
33	Human skills like empathy, relationships, improvisation, coaching where machines are not so great
34	More T-shaped, stronger pillar in Data and computer science and general knowledge in processes, industries, business
35	Soft skills will continue to rise in importance as the rate and change of any particular technical skill will increase and evolve.
36	I think employees' ability to adapt in fast-changing work environments will continue to grow as a need. Responsiveness to challenges - using data and making tough decisions - will continue as well. The ability to work well in a team - give and receive feedback, manage up and across, and be held accountable - are also important.
37	I think Change Management will be a key element of what drives a successful hire in years to come. We are focusing less and less on the skills that they are bringing to the table and more on their ability to adapt to new situations. Programming Skills will always be important but managers are looking at soft skills and a flexible personality more than ever as well.
38	the importance of the top 5 plus the additional 4 listed will accelerate and become even more crucial
39	Work will be about flexibility, Independence and self-motivation. Workers will be required to work anywhere at anytime
40	That is a great question! I think the top 5 skills remain the same, but there will be new job categories as yet unheard of. (Who had a title like "director of social media" 10 years ago?)
41	Everything I see leads me to believe that students are more careerist, and more conformist. Leading to less risk taking, less intellectual curiosity.
42	more computational skills will be important and critical thinking about artificial intelligence and machine learning will also grow in significance
43	I think technical skills could change. For example, Python is a key computational skill in data science now, but it wasn't 10 years ago, and it may not be 10 years from now (in terms of importance). Preparedness may change in the future, as something like Python might become more common across people (maybe akin to something like email as a skill going from niche to extremely common). I think soft skills, such as creativity and communication, will continue to be critical and

	not change in terms of importance or preparedness. Ideally, higher education could make people more prepared with soft skills, but I don't anticipate that happening in the near future.
44	The above skills will be weaker due to all the focus on mobiles and devices and less on people, communication, interactions, and personal growth.
45	desire to innovate, having backbone where always the skills that lead to human progression. Right now, we have a society that just want things, accept 'common thread' without thinking. At school - we need to put the emphasis on desire to learn new things, to love to discover, and have ability to not compromise 'for the sake of social cohesion'
46	We will have to go back to basic skills of STEM, that will drive analytical thinking. Understanding of core subjects is and will be important. Industry will have to get more involved to develop students to meet their needs. Vocation training will be of paramount importance.
47	The gap between important skills needed to be successful, and the curriculum deployed in colleges will likely continue to grow because there does not seem to be an effective feedback loop between enterprises and educational institutions resulting in a vital and continuous adjustment of college curriculum. Hence, I believe, new hires will be less prepared than today.
48	Automation will simplify the selling experience for sellers and customers. Tools will become more intelligent.
49	I see an increased emphasis on "Soft Skills", especially with the potential emergence of AI.
50	Will become more focused on collaborative skills, technical skills will become more specialized.
51	I think that services will be more and more important. This is the big differentiator for business.
52	Solid base knowledge and skills rooted in STEM (and STEAM) will provide a path to future skills. With constant change and new technologies, new methodologies, and new ways to work, employees will be challenged to envision which path(s) to investigate that are attuned to their strengths and to where they can address any weaknesses.
53	I think the ability to quickly learn new technology and exposure to customer facing skills will become more important
54	All is moving to cloud, software is eating the world with analytics, programmability and automation, but there will be a new wave in 5 years where Artificial Intelligence will be Software 2.0
55	Collaboration, Computational and Communication Skills would be key of ideal candidates for hire
56	Adaptability would be very important in the future!
57	Skills in customer service and creativity will be more in demand
58	More interdisciplinary skills, more human and soft skills, more compassion.
59	Even greater dependency upon the Top 5 skills identified, with the ability to re-skill and re-invent individual capabilities being a new Top 5 (possibly top 1)
60	It will change according to the business needs. Businesses will increasingly need more analytical skills and system thinking.
61	Understanding the relationship between development, productization, and

	consumption costs to innovation. Why great ideas fail and how to differentially and progressively invest in ideas as they move through the productization process.
62	Much greater reliance on Adaptability, Emotional Intelligence, Grit, and Creativity.
63	I think we will see more of our new employees have higher expectations from management in terms of how we manage, train, and prepare them for organizational change.
64	I think people skills will continue to be even more important, along with cognitive flexibility because of the constant changing environment.
65	They will have to improve. COVID-19 response is pushing virtual communication and, likely, work crafting more broadly
66	These are foundational skills. Don't expect them to change significantly
67	Soft skills and data analysis skills will be more and more important while classical hard skills will be replaced more and more by software. Judgement on software results will be crucial.
68	Change
69	More ubiquitous data and analytical skills
70	The digital medium will profoundly change the way people acquire skills. New ways of learning will greatly influence the quantity and quality of information disseminated

Appendix F: Detailed Answers for Q 3.1 - Thinking about recent graduate hires in your organization, especially those going into a project/corporate management job or career path, what are your organization's expectations of skills?

1	Be a quick learner. Be flexible to learn new things and change your skillset based on business needs.
2	Learning skills with strong subject knowledge to be become productive quickly and adapt to the organization.
3	They can manage their time, understand abstract concepts, and document those concepts in a way that non-technical people can understand the issue
4	I expect them to be able to quickly pick up new technologies and be confident in taking on tasks in domains they haven't seen before, knowing when to seek help and how to effectively engage others both in learning the processing and formulating their results.
5	Collaborations skills
6	In addition to delivering projects, they're expected to increase sales, develop new projects and new clients - help the business grow.
7	Exposing the new hires to customers and technologies that they otherwise would not have exposure to while at school
8	High leadership and analytical skills, comfort with technical areas.
9	Must be able to analyze a business problem, develop a vision the best solution, and execute on it.
10	Maturity, comfort with technology and analytics, curiosity and interest to continuously learn.
11	work independently and know when to escalate/ask for guidance. Technical skills are commodities anymore; a given. Differentiation comes from the ability to recognize failure, self-correct and bounce from adversity.
12	Strong business acumen, project management skills, communication skills, people management skills. Good understanding of technical areas like data science and AI and ability to manage experts in those areas

13	My Startup can't flex the recruiting muscle that bigger companies have, but we offer intern-geared perks, like hands-on experience, and thus we are able to snag quite a bit of talent. Since few candidates check every box, we prioritize the skills that are essential for each position and then fill in the gaps after the candidates are hired. We provide training and onboarding as part of the recruitment process, however, expect the employees to be proactive in their own training, (if they lack skills in design, we set up them with another employee so they can help each other). We focus on training the right candidate with the right attitudes rather than hire the wrong-but-experienced candidates. We expect them to be proficient in computers, and social media tools. We expect them to be able to find solutions to problems they don't know through an independent search on the internet or tapping into online communities.
14	I want them to be able to take direction, meet deadlines, ask for help, and to bring something to the table. I want them to be worth the money we pay them.
15	Ability to manage projects large and small, ability to adapt to internal/external changes, ability to curate content and data to make informed strategic decisions
16	We expect them to be autonomous, inquisitive, self starting and creative. We expect that they have a thirst for knowledge and we provide a variety of learning opportunities to learn via a virtual didactic experience to serving as an observer or project manager for a large project.
17	The expectation of the new graduates that we are hiring is about learning skills and how they can quick learn a new skill and apply to it. Every company is different and they need to have that capability to adapt. I also noticed today's new graduates are very aggressive on their career path and my organization needs to adapt to support their career advancement.
18	Analytics and collaboration no changes expected
19	High ethical standards, patience for doing the right things in the right way - positive leadership edge journey using AI and other technologies to enhance productivity
20	We expect each person to invest in developing their technology skills.
21	The current expectation is that people are walking in the door with project management and management skills at a level of "independence" (meaning that they do not need ongoing, daily support to do their roles). People that are promoted into these roles internally, however, how to develop them on their own - they are often not invested in, and this leads to discrepancies in leveling and experience within a role or job level.
22	Reliability Originality of thought/creativity Collegiality Awareness of and ability to organize towards corporate mission

23	Foundational skills - analytical skills and logic/problem-solving - need to be solid. The first 5 years is focused on the development of core technical skills. The undergraduate STEM education provides the foundation for that start. (Side note: I recently developed an internal Brown Bag series that started with What to Expect after Graduation and has developed into a 4-part series in 5-yr periods (1-5, 6-10, etc).)
24	Creativity and finding better ways to get things done
25	As applied to effectiveness in advancing the corporate mission, an analytical approach to understanding stakeholder needs must be combined with critical thinking about our solutions, proposed modifications, as well as the effectiveness of current or proposed new processes and individual performance.
26	Unfortunately, the current higher education system trains students in silo departments/disciplines, and also most students are spoon fed. They are not ready for search and find solutions for problems.
27	Some times a masters (either science and business administration) is considered helpful.
28	They need to fit culturally and they need to show an eagerness to learn from more experienced colleagues. Then, they need to work independently.
29	Ability to keep on learning, adapt to new technologies and coworkers, work in cross functional teams
30	Depending on Job, good computer skill, quick to learn, open minded
31	Collaboration and communication skills are key in working with a worldwide peer group.
32	We expect that individuals will be able to execute tasks with ease, manage their time, give and receive feedback, be able to learn how to use data to inform decisions,
33	I don't hire a lot of non-technical roles for VMware. I lean more technical.
34	that they have the basic concept to the extent that they can "self develop" and build on it with guidance and coaching and doesn't require formal training
35	self motivation, willingness to complete desired task, ask for guidance or assistance. live company values, bring new ideas
36	that they be able to hit the ground running and be able to start contributing 30 minutes after their orientation meeting.
37	My organization expects them to be able to hit the ground running with their technical skills. However, there is some expectation of ramp up time and acculturation, usually months to a year. I think this is particularly the case for my corporate organization / group that tends to hire many right out of college / grad school that do not have corporate experience.
38	More adaptability, agile framework, decision making without full/perfect information. Play a stronger role in team strategy & expanding their knowledge.

39	hands on technology skills, communication, adaptability, listening - so more on the soft skills
40	Attitude to strive hard to make the difference for all the stakeholders they work with. Critical thinking and curiosity to understand the goals, approach of the company and the market needs.
41	New projects need knowledge of "the Cloud". The way systems are designed, developed and operated in the cloud is rapidly evolving. Virtually all new programs will be deployed in the cloud and all new candidate need to have some knowledge of the cloud. Cloud also enables analytics and data processing which is and will continue to be important
42	New hires need to have good people, decision making skills and be comfortable with learning new systems and processes.
43	Experience in Agile Project Management & Sprint Methodology.
44	Good base knowledge of workflow expectations, understanding of PRINCE2 project management, presentation skills
45	Business language not just academic understanding, Workforce needs to hit the ground running.
46	A higher level of fluency in the prospected job area is desired, yet, the learning required for the career paths are documented. In some cases, the required acquisition of the skills is not entirely available depending on geography, job responsibilities, opportunity.
47	Strong technical skills (mathematics, analytical skills, software development and tools), communications, leadership and ,"soft" skills (people relationships),
48	Fast Learning, high level of collaboration with Senior people and understanding that career growth is a journey, not just something that happens only because of the skills set brought by the new generations
49	To understand the fundamentals, as graduates, and have an attitude of learning and growth, and be well prepared to collaborate with a global workforce
50	Hard working and soft skills that allow people to work in teams
51	Soft skills like coordination and time management
52	Good self-discipline and dedication.
53	Being able to utilize analytical tools to address business issues very quickly.
54	That the new hire spends majority of time learning about the business, developing relationships with co-workers, become integrated into the development process, and work within the development process guard rails. New hire should be up to date on current state of open source technologies in their specialty area.
55	Stellar communication skills. Ability to coalesce various pieces of disparate information, form opinions, act on those opinions, and adapt to required changes.

56	Cisco expects their new employees to jump in head first. We provide little training and expect the employee to be hyper-inquisitive. We expect the employees to be a "swiss army knife" of skills and tips and tricks.
57	They look for general cognitive ability to solve problems.
58	I have high confidence in our hiring to match the stated skills - but I'd like to see the bar set higher for those skills. We need fluency in virtual work practices.
59	Effective Communicators Collaborative Knowledgeable in the field Decision Quality
60	Improve
61	Increased and continued external awareness while developing as an employee
62	Definitely looking for skills related to faculty to learn and adapt from experience as well as contribute to the collective endeavor.

Appendix F: Detailed Answers for 3.2 How will these expectations of skills for new hires in a project/corporate management job or career path change 5 years from now?

1	change is the only thing that is constant. Those that can adapt to change quickly will survive. Others will struggle.
2	Adapting more and more technology into the work environment
3	The expectation to translate complex issues into concepts that non-technical people can understand will increase.
4	The core points above will persist, as they are pretty fundamental the tech industry, but I would expect more specialized knowledge in domains like data science, entrepreneurship, and innovation, so they can both effectively take on assignments and have solid ideas on how to optimize the projects to which they are assigned.
5	group projects and team work will be key
6	I don't expect it to change – it is the core of our business.
7	Bringing them up to speed much faster depending how quickly technology is emerging.
8	More comfort with technical skills and a way to synthesize across business domains.
9	Organizations will be increasingly fluid and virtual. Ability to stand up ad hoc teams, and execute with them will be key.
10	will not change.
11	More critical and important; there is a trend toward less direct management involvement in task assignment and a focus on self-motivated growth in careers. Self advocation and ability to identify new opportunities will become critical.
12	Deeper knowledge of technical areas will be required as technologies evolve and create many choices for any particular business problem.
13	One of the biggest mistakes that today's hiring managers make is to focus too much on GPAs, majors or whether new graduates went to the right universities. I think moving forward, managers will learn to clarify what the role really requires. I believe the expectations will focus on a defined set of transferable skills: a healthy mix of soft and hard skills that really matter in the workplace. There is already a philosophy built around recruiting for competency rather than pedigree or even degrees. Transferable skills like leadership, communication, resilience and problem-solving will be predictors for future success.

14	As they grow I want to gain trust in them to take on more responsibility. It could free up time of others or there could be a whole new assignment in the office. This will allow my organization to do more which will benefit the County and the public.
15	It will be increasingly important that the skills of today are underscored with the human elements of the existing skills of today. Anywhere there is automation in roles, AI and machine learning will take them. This is not just for blue collar jobs, but white collar jobs, such as paralegals, wall street traders and HR.
16	These expectations will change whereby business acumen, comfort with ambiguity and creativity will be desired skills for any new hire. Often we find that our roles are ever evolving and the only thing that is constant is change. These are the basic building blocks needed and thus the change is that we will more heavily rely on these three skills.
17	The expectation of these new hires are they will be the main work force in our company and how they quickly build up their people management and collaborating skills and leadership skill will position them to lead the next generation engineering work force.
18	No changes expected
19	The expectations are unlikely to change
20	Will become a requirement.
21	There is more and more focus on independent learning - I believe that people will be more equipped to learn on the job - or prior to moving into these roles. There is also more flexibility for people to take "stretch assignments" (doing future role work within a current role) to learn on the job, or be mentored by others who have more experience.
22	Increased need for business ethics Managing decision-making in complex scenarios Prioritizing uncertainty, sensitivity analysis, and regression analysis over optimization modeling
23	The foundational skills will continue to be required. In the private industry, competing for projects (public infrastructure) often times has minimum experience requirements and licensing/certification requirements. Project management requirements need to be supplemented with technical experience to be competitive in the marketplace.
24	Opens the door to future advancement
25	I expect more matrix teams and cross collaborations inside and outside a company.
26	The key principles will not change. The tools and methods will evolve, but their effectiveness will still be evaluated against the same mission.
27	They need to be more tech sawy to find answers for problems.

28	Become more generalized with a few people super specialized.
29	I don't think this will change in the next 5 years.
30	Become more apparent
31	Even more mental flexibility, analytics and programming skills
32	I would expect those skills to continue to be important to success in addition to being able to network, connect, and simplify complexity as much as possible.
33	I think the most important aspect will be flexibility, critical thinking skills, and ability to give and receive feedback
34	will pivot more to business performance and business knowledge
35	ability to work in smaller teams, adapt to changing technologies, work with colleagues or other team members anywhere in the world.
36	They may be managing fewer people and more robots.
37	more social networking skills
38	I don't anticipate these expectations changing. Perhaps if work culture changed drastically, then acculturation ramp up time might change. But I don't see that happening. I also see application of technical skills ASAP being critical and staying the same in terms of expectations. Perhaps, if some technical skills become automated, then there could be an expectation of soft skills application sooner. For example, maybe communication with executives would be seen as more critical immediately, if data science technical work is automated.
39	More adaptation, review, and change of path in a shorter time frame. Quicker decision making and processes.
40	not sure
41	Core skills will stay the same.
42	These expectations will grow in importance and will likely become absolute requirements.
43	Demand for employees with better people skills and ability to use technology to help solution with customers.
44	I think technology companies have shifted too strongly towards "Agile for Agile sake". Even in the past few years, I have seen software and technology teams use hybrid models taking frameworks from Agile, Kanban, etc. based on use-cases.
45	change in the workflow - anticipate AI and machine learning may change the workflow expectations
46	They need to be up to date with latest ideas.

47	Stronger commitment to: asking for and taking in feedback from their employees; the ability to take an employee's perspective/point of view; understand how his/her function fits into the overall organization and how their business competes in its marketplace; needs to learn self-reflection; needs to know how to acknowledge and reinforce employees; needs to learn to stand up for the team when a higher-up directive isn't feasible or achievable; needs to learn to manage his/her own career; the patience to needs to learn to communicate with people of different ages, ethnic backgrounds, religions, political stripes, personality types and wide range of perspectives; must learn how to build trust and community at work;
48	Due to lot of new work being cross disciplinary in nature, the ability to communicate across people with differing backgrounds will become more important
49	I am not sure if will change much from previous point, but the thing incrementally will change is the set of technical skills required by the evolution of the industry
50	The emphasize on collaboration and communication skills would be higher, along with emphasize on technical and computational skills
51	More towards analytical skills
52	Unlikely to have changed.
53	Experience with and working knowledge of AI/ML tools, regardless of their area of specialty.
54	I don't think the answer to 3.1 will change in 5 years ("Stellar communication skills. Ability to coalesce various pieces of disparate information, form opinions, act on those opinions, and adapt to required changes.")
55	I think Cisco is ahead of the curve when it comes to our PM teams. Everyone needs to have multiple skill sets (development, organization, analytics, design, comms, etc.).
56	I think this will continue even 5 years from now.
57	People will need to be able to work in any context and be able to easily shift that context as needed. New tools, new demands all need to be taken in stride. We will be doing less of the work and instead more management of work done via automation, freelancers, etc.
58	Don't see them changing
59	Improve
60	More integration across the internal corporate world and external communities and entities
61	I wonder if artificial intelligence and data mining will meander in measuring social empathy, creativity, collaborative attitude, resilience of employees/candidates for hire.

Appendix F: Detailed Answers for Q3.3 Thinking about new hires in your organization, especially those going in a strictly technical job or career path, what are your organization's expectations of skills? (emphasize differences from above)

1	Develop organizational awareness, be able to understand the dynamics of power and how and who makes the decisions. Figure out how best to influence the decision-makers with rational arguments, facts, and analysis. Communication is key.
2	Currency with new technologies and be able to use platforms effectively, particularly ERP and CRM.
3	They need to come in with a clear understanding of project frameworks, and technical frameworks. There is very little training to get up to speed on these basic concepts.
4	Hands on experience with full stack coding is highly desirable, ideally with the latest programming languages and tools. It feels like there is a gap between the more theoretical learning in traditional CS programs and the very hands on but less architecturally deep programs in hacker boot camps and places like 42.
5	Delivering high quality projects - technically strong in design, computation, analytical skills, up to date on industry regulations, resourceful, problem solving skills.
6	Depends on the job level required, we may hire experienced individuals along with entry level less experienced employees
7	High technical skills and low to medium leadership skills.
8	Ability to master new technologies quickly, and to combine with existing will be key.
9	To have a more inclusive mindset and design not only for one segment / one demographic / one population but also think how underserved groups (visually impaired, disabled, old, veterans, divorcee, single parent etc.) could be included in the technical design.
10	creativity and ability to recognize a business opportunity - go for it - and be able to explain what iteration is needed; all, without direct management intervention. We're looking at every new hire to be an intraprenurial agent of change.

11	Strong programming skills in languages like Python, knowledge of Machine Learning methods, creativity in solving problems, strong quantitative analytics, reasonably good communication skills
12	Many software engineers are fluent in one (or two) coding languages, and this becomes their primary area of expertise. While this is typical, the best engineers are familiar with all of the relevant coding languages on a basic level. We do not expect new hires to be fluent in all the coding languages of the day, but we value candidates who are able to learn languages with analogous qualities (structured versus functional, for example), or by knowing a bit about different types of languages. The following is a list of Must have for any technical hire: CSS Analytical Skills Troubleshooting Technical Documentation Formulas Data Analytics Creativity Critical Thinking
13	I have told them they need to strive to be experts in their field. I want to be able to trust that they will have the correct knowledge in their field that the organization can rely on, and that the public can trust in. This also saves money to have more technical skills in-house and less reliance on outside contracts.
14	The ability to perform not just automated tasks, but being able to take a series of events and tasks to predict future trends and mitigate risk.
15	None that I am aware of
16	We have hired a few New to Career graduates this year and one of the selection criteria is how they can work within a scrum team to get the job done and how they present their technical work to a non-technical audience. Communication and presentation is a important aspect.
17	Analytical and collaboration I on
18	High ethical standards for working in open source communities, as well as lifelong learning - technical eminence journey using AI and other technologies to enhance productivity
19	Those going into a strictly technical role will also need to be deeply collaborative, need to understand how to influence without direct control and help influence business strategy.

20	There is far more expectation around a level of expertise BEFORE you are hired. The screens for these roles are far more regimented and strict - and there are more levels of screening before someone even makes it to interview.
22	No change in expectations from what is noted above.
23	Control logic creation along with HMI programming is essential.
24	Deep knowledge, dependable, analytical, methodical, and reliable.
25	highly skilled and keep up to date
26	The new hire must be able to analyze the safety outcomes intended, any applicable content in regulations or standards, evaluate the effectiveness of the current means in place, and identify new or improved solutions to achieve specific improved safety results, as well as the path to putting them into effect and analyzing the degree of positive impact..
27	Team work, problem solving, communication skills, search.
28	Solid understanding of science and technology. Being able to communicate on it.
29	People with technical degrees will be expected to be proficient and need less training except in the application of their technical knowledge.
30	To detect new technologies and see their potentials in a business and customer context: how can we continuously create value for customers
31	Looking for data scientists, AI and cloud expertise.
32	Coding and the ability to effectively break down a problem while offering a solution based on business evidence.
33	that they have the basic concept to the extent that they can "self develop" and build on it with guidance and coaching and doesn't require formal training
34	skills both practical and educational. ability to think beyond technology. willingness to migrate to other projects once completed
35	Life-long learner technical acumen
36	not enough data
37	Ph.D. in relevant STEM field from highest achieving universities in many languages
38	I think I mostly touched on technical skills in previous questions.
39	adaption to new skills, flexibility and appreciation of changes
40	Technical - need to understand data really well. Analysis of data plus analytical thinking. Self Drive is extremely important. We need all new hires to have the entrepreneur mentality and they should aspire to become one themselves.

41	Collaboration, problem solving, experimentation, and analytical thinking are among key skills expected from new hires. These are vital in order for new hires to learn the many other skills needed to be productive. In other words, I already see the gap in knowledge. These skills will enable the new hires to bridge the knowledge gap more rapidly.
42	Technical employees will need to leverage AI to better train employees based on their unique training needs, make offers based on customer needs.
43	A base set of knowledge and experience with domain knowledge (depending on the team) is key. We have had new hires / consultants unsuccessfully step into roles where they had no domain knowledge at all which was problematic. For example, if hiring in a role that involves developing on the Salesforce application, it is very problematic if the person has no Salesforce knowledge or experience.
44	Industry qualifications relevant to their role - need to be "plug in and go" so must have good awareness and knowledge of industry standard practice.
45	I think that there is less and less need for "strictly technical" jobs. Interaction with customers and users of the service is vital.
46	Our department hires exclusively university/college students for extended internships (8-month minimum, up to 16 months). Our needs fall into the design thinking and "SWAT team" technical resource. SWAT team members are recruited with technical skills so to provide them advantage in learning the IBM tool set (IBM Cloud including Watson, dashboarding, etc) so to provide them the ability to affect the skills learning in their schools via hackathons, or the technical learning events. Design Thinking interns allow us to scale to bring this learning to schools also.
47	experience with large data sets, independent thought and initiative , communication of technical ideas and results to business audiences
48	automation and collaboration to do silo busting
49	In depth technical skills in one or more area, as opposed to be generalists, key is to be specialists in specific areas.
50	Actually I personally don't think there is a huge difference, collaboration is very important even with the technical teams
51	Data Analysis
52	The ability to re-learn and re-skill is probably pre-eminent. A deep desire to learn new thing and the ability to let go of old areas of expertise if needed.
53	Understand Agile software development methodologies, can operate within that methodology, and that they realize it is a maturation process from QA, to development, to technical leadership.

54	The need to be able to identify the role Artificial Intelligence and Machine Learning can and should play. Must be able to make data driven decisions.
55	Certifications are critical to success at Cisco. Whether it's agile or a CCNA engineering certification, we want to ensure that you have the latest and greatest education.
56	General ability to change quickly on the fly if needed.
57	The difference may be more focused on testing for skills versus looking at past projects. What can the applicant do in the moment that fits the technical needs of the organization.
58	'- SME - Critical thinking - Situational adaptability - Self driven
59	Improve
60	Continuing to be up-to-date, adapting to new tech, and being hands-on
61	Ability to insert technical contribution in an economic, social and ethical context.

Appendix F: Detailed Answers for - Q3.4 How will these expectations of skills for new hires in a strictly technical job or career path change 5 years from now?

1	The entire technology stack is likely to be different 5 years from now. So, being fast learner and adaptability is the only way to survive in tech. industry.
2	Deep knowledge of technology platforms will be a prerequisite.
3	Having a technical skill set, alone, will not be enough. When machine learning offloads 80% of the 'work to be done' only complex problems, ones that require collaboration, will be the responsibility of the new hire
4	Applied Computer Science will continue to become the most prominent growth area for STEM graduates, so I would expect CS programs will increasingly need to focus on applied skills to complement and exercise the theoretical underpinnings that have been the hallmark of traditional CS programs.
5	I expect that new hires will be expected to be more technologically savvy and more efficient as a result.
6	Training our workforce faster and keep up to date with skillset required for the strategy going forward
7	Again, more skills to apply the technical skills and across various business areas and domains.
8	half-life of specific technologies will decrease.(pace of change will increase) so emphasis must be on adaptability and ability to learn new skills.
9	As more tasks and activities get automated, the "human" skills will play a bigger role. Also training the algorithms to "behave" will be very important (inclusive and human-centered design, bias reduction, ethics, security etc.)
10	Deeper knowledge of ML algorithms, knowledge of contemporary approaches, ability to exploit open source, expertise in Platform-as-a-Service and Infrastructure-as-a-Service
11	The technology is moving at such a rapid pace, new hires will have to commit to continual learning and education so their skills are still relevant. I think in 5 years there will much less emphasize on what you know, and how fast you can learn something, so perhaps the interview will look like something like this: Here is a new code, check it out, now how fast can you create a prototype in this environment, versus, let me see what you have done in the past.

12	I expect that as their skills evolve that they are able to streamline processes. I will expect a high level of communication back and forth as changes are made and implemented. I also expect to work together on policy changes so that technical implementations are smooth and correct. Communication is key.
13	We must be able to identify where the human element exists without automation.
14	None that I am aware of
15	Technology is moving so fast and today's latest technology will quick become obsolete. The new hires need to have a always learning attitude so they can grasp tomorrow's new technology and adapt.
16	No changes
17	The expectations are unlikely to change.
18	We will need to hire serial learners. Technologies change so quickly that we need a workforce who can learn just as fast to take advantage of them.
19	Even strictly technical jobs will need to better understand nuance, big picture, creativity, ethics.
20	No change in expectations from what is noted above.
21	Although computers and its programming are emphasized in classes today the PLC will always run the machines in the most efficient ways on the factory floor. More should be taught in the collaboration of the two to gain data handling and traceability
22	I think these would be very specific roles and responsibilities as the technology deepen.
23	continue to evolve
24	The key principles will not change. The tools and methods will evolve, but their effectiveness will still be evaluated against the same mission.
25	Perhaps in 5 years, new hires will understand more about the complementary applications that align to their education before the are hired.
26	Become apparent
27	Technology continues to integrate, so a lot of these specific skills will be built into the systems in 5 years. The technical job will require a broader understanding of the ecosystem and architectures to create new possibilities and synergies.
28	Greater coding proficiency coming directly out of undergrad. Higher expectation for CS students to start coding in HS.
29	Not much of change expected
30	Ability to translate this knowledge into another natural language, especially other than English

31	As noted above, if technical skills become automated, then expectations might change in terms of wanting soft skills to complement technical skills (e.g., communicating technical data science results, rather than producing them).
32	It would be great to follow 14 leadership principles developed by Amazon, and increase thinking outside the box, as well ability to work across connected ' ecosystems' - would it be workplace, industries, partnership
33	The skills mentioned about are core skills and I do not think they will change
34	These skills will become even more important over time.
35	I assume there will more demand for AI solutions.
36	I think specialization and 'micro-credentials' are becoming more and more important in order to step into roles. Especially in technology where a person can spend years with specialization in core application / language knowledge
37	less knowledge dependent - systems will prompt appropriate action.
38	What "strictly technical " jobs?
39	For future permanent positions, skills expectations for potential hires may be influenced towards those exposed to IBM technologies as this would provide a smoother and prepared transition into the workplace.
40	Due to the proliferation of technologies, the demonstrated ability to learn new technology will become more important, as well as to communicate it to others
41	most likely will be any technical job to automate tasks, but the AI will be a MUST
42	Critical thinking and creativity are going to play a key role, in addition to technical expertise.
43	Adaptability and self learning will be the differentiators of the future
44	Analytical skills
45	This will be the norm, not the sign of a high performance individual.
46	Understanding the end-to-end process of understanding the relationship between the business, available data, data manipulation, analysis of data, and converting ML/AI into practical business value.
47	The needed skills for technical jobs will look more like those of the project/corporate management ("Stellar communication skills. Ability to coalesce various pieces of disparate information, form opinions, act on those opinions, and adapt to required changes.").
48	I think there will be a convergence of skills and an expectation that you know how to lead people AND be a subject-matter expert, as opposed to being an individual contributor.

49	Continue down the path of constant change
50	The topics will change, but I expect the process will remain largely the same.
51	they won't
52	Improve
53	Increased digital collaboration and community building - managing bottom up
54	Pervasive adoption and use of co-creation methodologies.

Appendix G -Detailed Answers for Q 5.1 - Tools & Type of Tools – Brands

Spread Sheet	Excel (16), Google Sheets (4), Word, Sales Force, Planning Analytics, Smartsheet (2)
Presentation	Powerpoint (17), Google Slides (3), Word, PREZI, How to present an idea to a different audience, Camtasia
Database	DB2, Oracle (3), Cloudera, Mongodb (3), MySQL (2), SQLite, Microsoft SQL Server (5), Ruby, Relational DB, Cassandra, Karfka, Storm, Excel, Salesforce, NoSQL (2), Aurora, Snowflake, Dimensional Modeling, ETL (Matillion, Informatica, etc.), IBM Content Stores and various databases, Postgres, Hadoop , SAP HANA
Statistics	SPSS (4), R (4), Excel (4), Finance Enterprise, AI and ML roles only, Statistics, Excel, Finance Enterprise, AI and ML roles only
Analytics	SPSS (2), R, Google Analytics (2), Adobe Analytics, Watson suite of tools (2), Finance Enterprise, PeopleSoft, GCP AI library and basic ML knowledge, PowerBI (2), Tableau (4), Qualtrics, Periscope, Google Sheets, IBM Cognos Analytics, Cloud Pak, Excel (2)
Math Programming	R, SPSS, Matlab (2), HAXE, In House property tax systems, Watson (Machine Learning, Deep Learning, Artificial Intelligence), Python libraries, Excel
Programming Languages	Java (6), Python (14), JavaScript (3), Angular, React, C++ (2), Go, API, and IDE (Integrated Development Environment), R (3), HTML, XML, Open tech, APEX, Jupyter Notebooks, Node Red, IBM Cloud tools
Computer-Aided Design	Adobe X, Website program, AutoCAD (2), Bentley Microstation, Canva
Collaboration	Slack (3), Confluence, Google Drive, Agile/Scrum Methodology (2), Skype, Zoom, Google suites, MS teams, Confluence, Github, Jira, WebEx Teams (5), Bluejeans
Cognitive Assistant	Watson Assistant, Google's Call-center assistant, Hoot Suite, Slack, Box, Webex, IBM Cloud Cognitive services
Project Management	Git, Phabricator, Clubhouse, Asana, MS Project (3), PMI, Asana, Smart sheet, Scrum-Master, PRINCE2 (2), PM Centre of Excellence, PMM , Jira and Rally for Agile PM, Trello
Virtual Reality	Agile Techniques

Social Media Management	Twitter (4), LinkedIn (3), Facebook (4), Instagram (3), Sprinkler, Press Releases & Internet Page, hootsuite, Adobe Presentation and other visual media tools, Automation Tools

Appendix H: Detail Answers to Q 6.2 - How well is the academic credit and degree structure of higher education preparing students to work in your industry upon graduation?

Line Number	How well is the academic credit and degree structure of higher education preparing students to work in your industry upon graduation?
1	Academia is lagging behind in the latest technologies and platforms in the market. Open source platforms and packages are moving very fast. Graduating students lack hands-on expertise even in their area of expertise with the latest open source technologies.
2	It varies from University to University. Graduates from Universities with a focus on experiential education tend to be better prepared (stating the obvious!)
3	They are technically prepared, but not fully prepared for high collaboration and public speaking (communication skills)
4	Many Computer Science programs are still too focused on theory and algorithms, which are great for more advanced technology development like Google, but not as well aligned with being able to effectively jump into core programming projects without experience that's often learned outside traditional academia.
5	students are lacking many skills
6	They're not well trained in creativity, writing, soft skills, sales and business development and operations and financial side of business. On the tech side, not sure if our industry is taking full advantage on advancement in technological tools to be more efficient - e.g. automating our technical reporting processes.
7	It depends on the position within the organization.
8	The degree helps with analytical skills but business applicability and concerns and an ability to apply the basic skills to the business problems are developed at work.
9	It does a decent job of laying initial foundation, but provides little to enable lifetime learning.
10	In HR profession, the educational system is still limited in its innovation and still teaches for a world where the majority of workers are full time, regular employees, with traditional performance management, succession planning, training and development, reward and recognition, hiring and firing processes.
11	Depends on school. Data Science programs from Columbia and NYU are good - but they don't teach critical thinking as much as they should. Wharton MBA program is very good because it offers Business Management with Data Science as a major.
12	The assumption that education correlates with on-the-job performance is unfounded. In our hiring process, we found that education-based measures correlate very poorly with on-the-job performance. It seems that often the selection processes and criteria used by universities have very little to do with the characteristics that make one a successful new hire. Some of our best employees are self-taught and do not have degrees. In contrast, we had several graduates

	from Stanford with specific degrees such as design or photography, who took the worst pictures or presented the worst designs compared to those who bought a camera and taught themselves how to take photos. We noted that the selection process of even the best universities has rejected some potentially excellent candidates who are working for us now, while accepting less promising candidates, who simply could not perform at our job.
13	Our middle management jobs requires a degree. The education enhances their job knowledge. We do look for experienced workers.
14	4 year institutions are not able to adapt quickly enough to the evolving demand for human labor. The sales cycle and curriculum cycles for changing materials and getting approvals is years long, but often times the college is behind the curve of certification, which are easily adapted, created due to who manages/owns them.
15	Degree is desired but not mandatory. One of my best developers is home schooled and don't have any degree. But they should be able to write a program and debug a code piece during the onsite interview. These programming skills can be learned on their own. Listening capability should be there. I feel many candidates don't have this ability to listen to the questions and then answer to the point.
16	Need better T-shapedness (experience working across disciplines, systems, and cultures) and more open source experience
17	Academic institutions have been increasing relevance of practical knowledge in recent years. Programs which include/recommend/require internships tend to graduate the strongest talent.
18	The biggest area of lack that I see is in the areas of cognitive flexibility and resiliency. The current workforce is very good at sharing their thoughts and opinions, but not adept at adapting to change. I have also noticed that there is a lack of understanding or acceptance of hierarchy - and a keen need for all information to be shared at all times. There is also a lack of in-person communication skills - speaking vs. writing - knowing what to say and how to say it professionally.
19	Students get too much structure and handholding in the current system. They do not learn to take risks, to innovate, to deal with wide open business inquiry and innovation/investigation
20	Academic credit and rigor as a minimum requirement vary by hiring managers. For some, GPA is primary. For others, varied education is primary. Personally, I'd hire a 3.0 or a 3.5 GPA student with a varied education and worked during the summer, than a 4.0 GPA student that took summers off.
21	Very smart people graduating but no real factory experience of how things really work on the floor
22	There is need for the academic but also there is a need for practice in the actual field. Both complement each other.
23	The number of programs for BSc/MSc/PhD in Standards Development is actually or essentially zero. Current credits and degrees in individual programs can indicate proficiency in technical analysis, people management and consensus building, and textual analysis and development, but no program currently assesses all of these skills in one student.
24	Some curriculum seems outdated.

25	Healthcare insurance is a specialized field, so most college graduates require on the job training.
26	Education has a silo approach to topics or being able to pick courses across campus
27	I think they have a good base, but will need to learn and use the specific tools that company either builds or has licenses for. They also have to learn to work outside of their own department or organization to take advantage of the knowledge and skills that are immediately around them.
28	University and academic theoretical learning work for some but not all. Practical work experience is quite valuable but not always available in degree programs.
29	We focus primarily on undergrad, masters, PhD and MBA level talent. Degree leveling is very important to us to determine how they will drive impact best.
30	It depends upon the school. A "hands-on" school like Cal Poly prepares students to contribute on day one whereas a more research oriented university does not. It also depends on the role the new hire is expected to play.
31	Not enough data
32	It's very important since MIT OCW-centric wiki World University and School seeks to develop majors in all ~32 departments in MIT OpenCourseWare ... and in most of all ~200 countries' official languages.
33	Some things I think you need to experience without being prepared. For example, full exposure to a corporate work life is not possible in college. Internships can help, but it's still not the full experience. It's kind of like going on vacation (internship) versus living in a foreign country (full time employment). So, I think universities do a lot to prepare students, but they can never cover everything, especially things like acculturation, fit, etc.
34	It depends on the institution. Some has an excellent preparation, program, another - less technical more general.
35	The choice students have in choosing their subjects to graduate leaves a lot lacking. We would have a computer graduate majoring in Philosophy. We need defined curriculum with only relevant choice/flexibility in the course subjects.
36	Students do learn a range of skills. However, they are not prepared to solve problems, design experiments that help find answers, be able to reduce large problems into components and navigate towards solution. They are not expected to know the solutions. But, having tools and the mindset necessary to progress towards solutions will go a long way to help their success.
37	Telecommunications is specialized area and requires additional training.
38	There are multiple people on my team who have no college degrees including our lead senior software developer. I think academia is a bit behind when it comes to Internet Security and Business Operations (via Information Systems such as Salesforce) domains. Business Intelligence I have found academia has prepped students / prospective candidates better.
39	Dependent on the degree that they have come in with. Some broad knowledge must be baked into each degree that will help prepare them for the rigors of daily work.
40	Degree informs us that they know how to learn. Because of the structure they are often not up to date and almost always have a lock of business language/understanding.
41	As we engage interns for the most part, it depends on the depth of technical

	training that the students have already completed and the program year that has been completed. Additionally, the teaching methods and the proficiency of the student to understand and retain what was taught is a factor.
42	They know the math and software skills but haven't experienced big data sets or working with customers and partners
43	Depending on the country there are different levels. In the USA I guess depends on Universities
44	There are a few schools in computer science which offer academic programs and curriculum that prepares the graduates for the job market. However, a larger group still teach either traditional or outdated materials, or non-essential to the market and industry needs.
45	Academic curriculum is very theoretical, generally does not use/teach software or programs that the industry uses.
46	We see graduates with general software development and lack the networking and network automation knowledge needed
47	Even with co-op programs, the current higher education degrees we rely on concentrate on what the students know rather than what they can do...and more specifically how to manipulate data to arrive at novel conclusions to act on.
48	Academic institutions could prepare students for RAPID change. Our jobs in IT change every month due to macroeconomic factors, customer demand, and innovation.
49	I think it really depends on the degree and institution and is very different for each program and school.
50	Only in a few instances (where the university and the company are working together explicitly) do I think the match is perfect.
51	Our new hires have higher education and usually come in well prepared to apply their expertise on the job they start

Appendix I: Detail Answers to Q 7.2 - The use of verifiable competency and skills certification/badging in relevant job function areas as complement to academic degrees and preparation in hiring decisions

Line Number	Sample Success, Opportunities, and Challenges comments:
1	For question 7.1, I wish there was a “yes & no” option. The quality and validity of badging programs, modules vary too widely.
2	Certifications may get more meaningful as they are conferred on people outside traditional academia, but at this point coding challenges tend to be the primary metric. This is a decent practice but well-constructed certifications in specialized areas (e.g., Data Science, Full Stack development) could be helpful.
3	This just doesn't come up too much in our hiring in my group, but in the broader company it is a big factor.
4	There are many educational opportunities and content (MOOC courses, boot camps, networking events with an educational component etc.) where people can further their skills and those are important ones to account for, but also to consider the mindset of such individual (who pursues their intellectual enrichment, networking, and learning on on-going basis)
5	Not too many industry standard badges in Data Science so far. Needs greater adoption across the industry. IBM is promoting the idea of badges for Data Science
6	If we are hiring for a designer who might not have a 4-year degree but tons of volunteer opportunities or has won certificates by learning online, we still consider them and often they are better on the job than the degreed candidates.
7	We do have some that require certifications in public health and behavioral health. Certifications can be preferred depending on the focus of the organization.
8	Certifications tell a story, beyond a 4 year degree.
9	We have hired many great talents in the last few years. Some of them are fresh graduates who have interned in my company. They have proved their abilities to work with us and get many high recommendations from my managers. Challenges are talent is very scarce in Silicon Valley area and many companies compete for the same talent and we always lose out on the name brand recognition. However, certain candidates are interested in learning more advance technologies and smaller environment to shine and that is where we had some success in hiring.
10	IBM is a huge supporter and adopted of badges in all technical skills areas, and certain methodologies such as Design Thinking and Agile.
11	We currently do this internally for some key skills within our Engineering teams.
12	For question 7.1, I wish there was a “yes & no” option. The quality and validity of badging programs, modules vary too widely.
13	It is more based on their previous experience and judgement and verify with references.
14	certifications are very valuable
15	Personally, for new graduate or experienced hires, I tend to be wary of academic stamp-collectors. I look for demonstrated skills in real environments such as work

	experience or volunteer activities in place of a string of accreditations based on specialist exams. For example, I don't hold a PMP certification although several of my colleagues do, but I am confident that, for actual on-time, on-cost, in-scope completion of our separate projects, my record is demonstrably better than any of theirs.
16	Certificates are nice-to-haves (PMP, college-sponsored non-degree programs)
17	Most programming skills are related to moods or on top training
18	certifications typically represent more practical knowledge and serve as a compliment, not a replacement, to academic grades
19	Certification achievements make possible a kind of lifelong learning.
20	They may be on resumes and given some consideration, but it is not nearly as critical as degrees and past experience.
21	We like to see more certifications and/or badges. However, new hires do not have many certification/badges.
22	Require bachelors or master's degree in STEM field: Computer Science, Engineering, Data Analytics
23	We do consider it; however, it is key to note we also consider it a 'red flag' if someone makes certifications the highlight of their credentials. We value personal experiences and real-world work the most by far.
24	As I do not do the interviews, I do not have any insight to provide.
25	Collaboration with Technical Organizations, self-developed companies and technical programs, participation in technical forums and as well giving back/charity activities
26	At Cisco we value coding/analytics/engineering certifications, but it's difficult to obtain while in a degree program if you don't have the idea that you want to work for a specific company. For example, Cisco has Cisco-branded certifications.
27	Google does not have a college degree requirement.
28	I can agree with "compliments." The outcome would still be based on an interview practicum or other demonstration of skills.
29	SAFe, Leadership Training, Salesforce, Negotiation skills
30	The tech community itself is motivated by badges

Appendix J: Detail Answers to Q 9.1: Has your organization been able to access a sufficient number of US university bachelor's degree graduates from STEM programs as job candidates over the past few years?

Line Number	Has your organization been able to access a sufficient number of US university bachelor's degree graduates from STEM programs as job candidates over the past few years?
1	Yes, I'd say. The pool exists but there is a lot of competition too.
2	There are shades of gray within STEM. Computer Science grads are the hardest while the supply of Physical Sciences is still in balance with demand.
3	We are a high growth company and have a massive influx of candidates for technical roles
4	The vast majority of applicants for CS positions in Silicon Valley seem to be educated (at least undergraduate) in India or China, and there is a huge gap in the number of people graduating from US universities with CS skills relative to the increasing job openings requiring computer skills.
5	There is fierce competition for top talent, and not enough qualified technical applicants.
6	Those students are in high demand and big (or cool) brands have a higher success rate at attracting them.
7	Yes, but we have had to sponsor H-1 visas to get the best candidates. This is very challenging in current US policy climate. There simply are not enough US Citizens available with the required skill set.
8	We are a Startup in Education, and thus raising investor funds has been a challenge. Most Silicon Valley VC's value deep tech, or want a unicorn, they don't value education. Yet for our software to work, we have to hire top-notch engineers. We did receive a government grant of 1Million from NSF, but in order to hire two top-notch engineers, we would already need a Million. We have to compete with Google and Facebook for talent, at Google a Level 7, which is considered the top level for the vast majority of engineers, can make $608,000, plus free food, dry cleaning, ride to work, etc.
9	We have a variety of fields. Lawyers, health, behavioral health, information technology, and public administration. Our applicant pools vary. Some of our hires have been luck, with people that have moved away from the Central Valley and have decided to come back.
10	There is not a direct link to these new graduates, beyond the career center of a university. There should be "career pathways" from University X to Industry/Corporate Y.
11	A good number of our technology SMEs are foreign born working on work VISAs.
12	We have dedicated internship program that select top universities to work with us each year. Again, the competition is high there and we have learned to go to 2nd tier universities instead of first tier to have better attraction.
13	We typically have 200+ applicants per job opening - however, in some areas such as artificial intelligence and data science - the competition for the top 10% of talent is extreme, and may lead to perceived shortages of "top skilled" applicants from the top universities.

14	The core talent pool continues to grow however one of the biggest challenges is maintaining continuity of the workforce as attrition levels continue to be high with average tenure in the 2 year range - which is not long enough to build and benefit from required institutional knowledge.
15	we have no issue hiring new grads - challenges lie in hiring experienced leaders.
16	Not really relevant to me but there is no option so I kept it neutral.
17	Sometimes it was hard to find candidates with the right degree in STEM. This is very valuable and in high demand in the industry.
18	I am approaching 60 years old, but ever since I was an undergraduate I have been reading about the "imminent" shortage of qualified STEM people. This is a popular myth, that gets repeated in other fields as fashion dictates, such as truck-drivers or plumbers. Between available native talent and focused immigration channels, the G20 nations will never lack for technical talent.
19	We struggle to hire top college graduates in STEM because they prefer to work in high-tech if they settle in RTP.
20	Germany based company
21	Fighting for women in tech and data science skills.
22	We have no concerns around this. Quality applicants is never an issue.
23	always managed to get qualified candidates
24	We sometimes get outbid by competitors and of course all of the students think they want to work at Google, Apple, or Amazon who between them hire tens of thousands of new college grads while we only hire ~ 30.
25	I think World Univ & Sch will need an enormous number of these, perhaps beyond what we'll be able to find in Handshake and similar college intern hiring platforms.
26	It would be great if additional degrees would be classified as STEM. For example, many social science degrees that go quite deep on the technical front are not considered STEM (e.g., some economics, psychology). That limits opportunities for my organization and potential candidates.
27	I don't know. I hope so
28	Very few with relevant education available
29	We’ve been able to receive STEM applicants for technical positions.
30	It is challenging to hire in the Bay Area due to competition. I think this is more a reflection on the local economy than anything else.
31	I have limited visibility of this in my role.
32	My response is based on Canadian universities/colleges.
33	Most of our data scientists have BS degrees from abroad and then graduate school in the US
34	Our brand brings people very interested to join us
35	In my department, I focus on hiring PhDs and not undergrads, so my response here may be less informed.
36	Not all of the candidates are excellent, but there is a good flow of candidates
37	Do not have access to Top Tier school STEM graduates
38	We need a more diverse population. We have quantity (450 university hires in our function last year) but not the quality and diversity of candidate we are

	seeking.
39	Cisco has a lot of outreach to universities but in my opinion, there are not enough STEM students.
40	They have programs to hire from each university.
41	We have an active college recruiting program

Appendix K: Detail Answers to Q 10.1 Additional Comments and Questions about the workforce, your industry/organization requirements, and the road ahead in the next five years.

Line Number	Additional Comments and Questions about the workforce, your industry/organization requirements, and the road ahead in the next five years.
1	Agility, life-long learning, adaptability, flexibility are key to surviving and thriving in tech. industry.
2	It's really important that we train a workforce with practical computer skills ranging from traditional Computer Science to effective coding on the latest tools to more generic IT/DevOps skills like AWS certification so there is a larger set of qualified candidates spanning a range of skill areas. Apprenticeship programs would help.
3	Technical skills, creativity, people skills, and communication skills are needed in each worker in combination. But most candidates have only one side of that rectangle.
4	There is growing polarization of labor-market opportunities between high- and low-skill jobs. The development of automation enabled by technologies including robotics and artificial intelligence brings the promise of higher productivity (and with productivity, economic growth), increased efficiencies, safety, and convenience. But these technologies also raise difficult questions about the broader impact of automation on jobs, skills, wages, and the nature of work itself. We will continue to see automation in the recruiting space. Artificial intelligence interviews are already taking place, and I foresee this expanding as a tool to make the recruiting process more manageable for employers. This will require individuals to expand their interview skills to become comfortable in an already high-stress situation with the added challenge of speaking to a machine
5	The next five years are going to be fiscally challenging for local governments. Cost are rising faster than revenues, and organizations are going to have to be strategic in keeping a talented workforce. Work environment and benefits are important. Education and communication will be important.
6	I would like to see more diverse candidates in the hiring pipeline. I truly believe diversity increase business agility. However, in STEM area, I still have very small section of the pipeline and that makes building my diverse workforce challenging. I have about 10 direct reports (Sr. Directors and Directors) and about 300 people in my organization. We have a global team including Silicon Valley, Singapore, and Warsaw(Poland).
7	The "hot topic" technology area continues to change every few years, and the competition for the top 10% of talent is fierce.
8	As we continue to grow the company exponentially, we need to be more flexible around remote working and where we hire from. AI, blockchain, infrastructure, data, privacy and security skills will be key.
9	College costs so very much more but the degree doesn't produce jobs pay what certification jobs pay. Numbers below used by Thomas Frey - Futurist Speaker Example Top Paying Certification Based Jobs: $139,529 – Google Certified Professional Cloud Architect $135,798 – PMP® – Project Management Professional $135,441 – Certified ScrumMaster® $132,840 – AWS Certified Solutions Architect – Associates $130,369 – AWS Certified Developer – Associates $121,288 – Microsoft Certified Solutions Expert (MCSE): Server Infrastructure $120,566 – ITIL® Foundation $118,412 – CISM – Certified Information Security Manager $117,395 –

	CRISC – Certified in Risk and Information Systems Control $116,900 – CISSP – Certified Information Systems Security Professional $116,306 – CEH – Certified Ethical Hacker $113,442 – Citrix Certified Associate – Virtualization (CCA-V) $110,321 – CompTIA Security+ $107,143 – CompTIA Network+ $106,957 – Cisco Certified Networking Professional (CCNP) Routing and Switching NOTE: Dollar amounts reflect average salaries currently being paid. This is the first year for the Google Certified Professional Cloud Architect. Top Paying College Degrees 2019 Mid-career salary: $175,500 Actuarial mathematics – Early career salary: $56,400 Mid-career salary: $131,700 Actuarial science – Early career salary: $61,200 Mid-career salary: $130,800 Nuclear engineering – Early career salary: $69,000 Mid-career salary: $127,500 Chemical engineering – Early career salary: $70,300 Mid-career salary: $124,500 Marine engineering – Early career salary: $73,900 Mid-career salary: $123,200 Economics and mathematics – Early career salary: $60,000 Mid-career salary: $122,900 Geophysics – Early career salary: $54,100 Mid-career salary: $122,200 Cognitive science – Early career salary: $54,000 Mid-career salary: $121,900 Electrical power engineering – Early career salary: $68,600 Mid- career salary: $119,100

Appendix L – Further Research Recommendation

As a result of the COVID-19 crisis, some aspects of work are getting harder, some easier, some technology and cultural transformation are being accelerated. To study the long-term impact of COVID-19 on future of work, jobs demand, and skills, the research team recommends NSF to fund a project to accomplish the following:

1. The study would first focus on getting the Expert Panel perspectives about what the “new normal” will look like in the wake of changes set in motion by the COVID-19 pandemic.
2. Then the study would focus on getting data on jobs/skills/education perspectives about the next 12-24 month as the period of transition to the "new normal.”
3. Finally, a synthesis of #1 & 2, will look at the long-lasting impacts of this very formative transition period on skills and education, still with a longer term (5-10 years) horizon.