OREGON ENGINEERING & TECHNOLOGY INDUSTRY NEEDS PORTFOLIO 2014

OREGON ENGINEERING & TECHNOLOGY INDUSTRY COUNCIL

ETIC

Dear Colleagues,

Welcome to the 2014 summary of key industry needs as identified by the Oregon Engineering and Technology Industry Council (ETIC). These needs statements provide a framework for evaluating one-time and renewable investment opportunities in Oregon universities by both ETIC and industry partners. In these needs statements we answer questions such as:

- What is the industry unable to do, or do well, at this time as a consequence of a critical, urgent, unfilled workforce need?
- Does Oregon have a unique opportunity?
- Why is the need emerging now?
- Does this need require new skills, or is it a capacity gap?
- How broad and predictable is the need?
- Who is serving this need now?
- What are the consequences if the need goes unfilled?
- How do you recommend setting up the education delivery system to best respond to unexpected or emerging needs?

Oregon ETIC, in partnership with Oregon's public universities, identified the following as urgent workforce needs in 2014:

- Cybersecurity Education & Research
- Lane County's Software Industry
- Engineering & Prototyping of Interconnected Devices
- Electric Power Industry
- Demand for Personalized Medicine
- Big Data & Data Scientists
- Developing T-Shaped Professionals

We expect to revise this portfolio on an annual basis.

Sincerely,

Chris Brooks
SVP of Technology, WebMD Health Services, Portland OR
Vice-Chair, Oregon ETIC

Cybersecurity Education and Research

Abstract

Virtually every aspect of our daily existence relies on the "cyber-world" of the Internet and computers. This includes communications (email, cell phones, texting), transportation (traffic control signals, car engine systems, airplane navigation), government (birth/death records, social security, licensing, tax records), infrastructure (communications, energy, water delivery), finance (bank accounts, loans, electronic paychecks), medicine (equipment, medical records), and education (virtual classrooms, online report cards, research). Future business growth will have a heavy reliance on Internet connected devices and services and more of our infrastructure will be instrumented, increasing exposures and vulnerability.

Protecting the confidential information, transaction security and human safety means that cybersecurity (aka information security) is a necessary consideration for individuals and families, businesses, educational institutions and governments.

The three core principles of cybersecurity are:

Confidentiality: Information which is sensitive or confidential must remain so and be shared only with appropriate users.

Integrity: Information must retain its integrity and not be altered from its original state.

Availability: Information and systems must be available to those who need it.

These three core principles are supported by three primary areas of industry and education: hardware, software and managerial/psychological education.

Hardware: The physical elements and devices that support the secure processing of data.

Software: The machine-readable instructions that support the detection, prevention and encryption of data in motion and at rest.

Managerial/Psychological Education: The instruction and training necessary to better support and develop the "human firewall."

Protecting the core principles is the role of cybersecurity and these protective measures have become increasingly more difficult and the impact to the global economy, our personal liberties and America's national security are clearly in jeopardy. ETIC must consider its mission in support of cybersecurity through research and education.

Impact

The financial impact of cybersecurity is staggering. According to the United States FBI's 2012 Internet Crime Report, over $525 Billion was lost by individuals and businesses to various cyber-crime schemes. This loss was up 8.3% over 2011 and up more than 2000% since 2008. The top 10 states are shown below; Oregon ranked 24th at 1.49%.

Background and Scope

There are a number of significant regulatory, procedural and industry-based best practice initiatives underway in support of cybersecurity. These include the Obama Administration's Comprehensive National cybersecurity Initiative, Homeland Security's cybersecurity Internship Program, the PCI Security Standards, and the recently announced Unified Compliance Framework's (UCF) industry-led harmonization of cybersecurity compliance objectives. In addition, cybersecurity guidelines such as FedRAMP, CAESARS, and SAIR Tier III in the US, as well as an increasing number of global cybersecurity initiatives such as the BSI Act in Germany and CIP/CIIP in Australia, all call for Secure Configuration

Top 10 States by Count: Victim Complainants (Numbered by Rank)

1. California	13.41%
2. Florida	7.98%
3. Texas	7.22%
4. New York	5.70%
5. New Jersey	3.81%
6. Pennsylvania	3.70%
7. Illinois	3.50%
8. Virginia	3.30%
9. Ohio	3.05%
10. Washington	2.72%

Note: 7.55% of the complaints did not include location information.

Management (SCM) and Configuration Auditing (CA) tools to communicate directly with Governance, Risk and Compliance (GRC) tools.

Many of these initiatives and mandates are designed to establish a front line of defense against today's immediate Cyber threats by creating or enhancing shared situational awareness of network vulnerabilities, threats, and events by aligning federal, state, local, and tribal governments, educational institutions and private sector partners in order to act quickly to reduce our current vulnerabilities and prevent intrusions.

A number of NSA and DOD initiatives are designed to defend against the full spectrum of threats by enhancing U.S. counterintelligence capabilities and increasing the security of the supply chain for key information technologies. These efforts seek to strengthen the future cybersecurity environment by expanding cyber education; coordinating and redirecting research and development efforts; and working to define and develop strategies to deter hostile or malicious activity in cyberspace.

Oregon has a number of companies engaged in these cybersecurity efforts. These companies supply a wide variety of products and services across the three primary areas associated with industry and education. Accordingly, it is incumbent on ETIC and Oregon Higher Education to explore ways to expand and support the opportunities of growth through the development of intellectual property, and delivering a prepared and engaged workforce.

The following is only a partial list of Oregon companies whose operations are directly tied to cybersecurity:

• ESI	• Intel	• Thetus
• EID	• TriQuint	• Cigna
• Tripwire	• Smarsh	• Lifecome
• ID Experts	• PuppetLabs	• Kaiser
• Cambia Health	• Prolifiq	• Providence
• Kryptiq	• OpenSesame	• Legacy
• EasyStreet	• McAfee	• ADP
• Galois	• Harris Corp	• The Standard
• IBM	• eBay	• PGE
• Zoomcare	• Walmart Labs	• NorthwestNatural
• WebTrends	• ShopIgniter	• CH2MHill
• WebMD	• Monsoon	

In addition, the State, the City of Portland and other municipalities, counties and government sponsored entities such as BPA and Trimet also face significant risk due to cyber-threats. There is a need to

produce students capable of contributing to the security and incident analysis of our critical infrastructure. This includes the development and application of high assurance forensics to address problems with infrastructure systems including Supervisory Control And Data Acquisition (SCADA) systems and other Industrial Control Systems (ICS.)

Activities

Market Assessment: With the support of the Technology Association of Oregon in cooperation with ISACA, AOI, OBA, and Oregon Biosciences Association a survey of Oregon industries was completed in 2013. This survey concluded that establishing a Center of Cyber-Excellence in Oregon is both feasible and practical. There is an established need within the state for:

Coordinated curriculum guidelines and recommendations for undergraduate (including Community Colleges) and graduate programs

Robust continuing education programs (including annual local conferences) to help cyber- professionals remain up to date on their skills.

Recommendations

- Establish an Oregon Center for Cyber Studies

- Encourage Oregon's Congressional leaders to seek cyber-centric appointments

- Develop curriculum guidelines and recommendations for undergraduate (including Community Colleges) and graduate programs

- With ongoing industry dialog to keep these programs and requirements current

- Consider targeting niche yet critical areas to allow Oregon to differentiate from other states, such as the protection of very large distributed networks of control systems

- Define certification programs and internships

- Expand cyber-centric research activities

Investment Quality

Combining the strengths of our education system with industry's needs is a proven combination that pays huge dividends.

For the State:

Cyber-centric employment opportunities are knocking; we must answer with an educated work force. This ETIC proposal supports the consolidation and establishment of cyber-centric programs that will support the industry's current and future needs. The creation of a Center for Cyber Excellence will not only better prepare Oregon's students for the jobs of the 21st century, but will also enhance our state's economic competitiveness.

For Higher Education:

The Oregon Higher Education has a proven track record for creating research institutions to meet challenges and solve problems through discovery, innovation and application. Cyber-research projects offer an opportunity to gain significant new grant funding and develop new areas of collaboration with other leading research institutions. A Center for Cyber Excellence has the potential to create new public-private business partnerships and gain the attention of the National Security Agency and the Department of Homeland Security.

For Industry:

More than 100 Oregon companies are directly involved in cyber related commerce. But every Oregon company can benefit from better prepared employee can meet the diverse cyber-centric demands of today's very technically enhanced work environment. Whether the goal is hiring an entry-level office worker or a research scientist, cyber education and training are key ingredients to ensuring Oregon a competitive market edge now and in the future.

For Graduates:

Graduates increase their earning potential by developing and refining their capabilities during college. By providing an opportunity for students to focus on cyber-centric jobs students will learn advanced techniques, gain certifications or earn degrees designed to vie for a higher wage. Based on median annual wages, compensation for cyber security professionals ranges from $70,000 to $118,000.

Lane County's Software Industry

Abstract

High-Tech industry in Lane County, and software publishing firms in particular, require more assistance from postsecondary institutions to meet their workforce needs. There is a shortage of qualified graduates produced by local universities and colleges to fill projected demand for coders, software developers, and other computer science fluent occupations. Software publishers want "T-shaped professionals" with business and career skills, too. There are also several opportunities for strategic investment unique to the Eugene-Springfield metro. Education funding could potentially leverage state investments in the Regional Accelerator and Innovation Network as well as federally funded research at the College of Education.

Impact

An Urgent Need

The custom software publishing industry in the Eugene-Springfield metro has outperformed the nation and the state of Oregon as a whole by its rate of job creation (Figure 1). In the next ten years, software publishing in the Eugene-Springfield metro is projected by the state employment office to grow 1,105 jobs by the year 2020. Another 1,258 jobs will need to be replaced. If Lane County businesses are to keep pace with Oregon Employment Development projections they will need to either develop or recruit 2,363 employees by 2020—during a global shortage for skilled software specialists.

However, corresponding investments and improvements to the quality of higher education services in computer science instruction in the South Willamette Valley
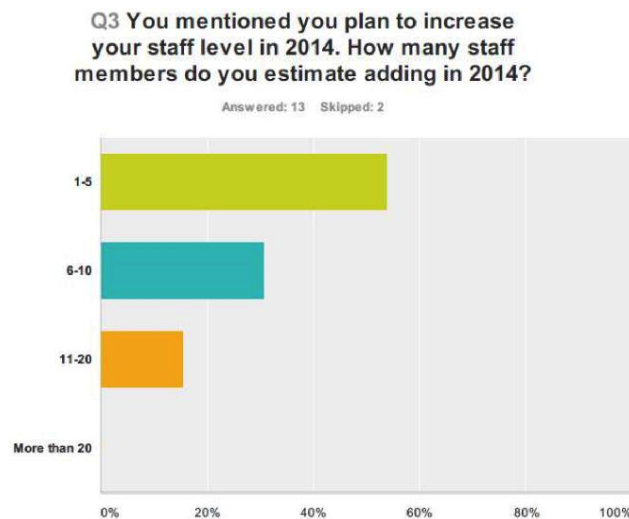
have not kept pace. The parallel of a robust, growing software industry and declining resources for computer science in this region's postsecondary institutions has alarming implications for meeting the projections. More importantly, many local businesses have felt there is insufficient outreach or targeted attempts by the postsecondary system to capture talent or press students towards local software community networks while they are in Eugene. More can be done to prevent many South Willamette Valley postsecondary graduates in computer sciences—some of the state's best coders and potential software entrepreneurs—from moving out-of-state.

Moreover, the quality of education at local postsecondary institutions in the eyes of many business leaders is often out of date and insufficient for their needs. If students graduating local colleges had more practical coding skills and understanding of common software business practices, then their transition into the workforce would be made easier. Training new employees in basics of team-work (such as version control and software deployment in web processes) is costly for employers with companies under 100 employees. The relative small size of these firms, however, is not an indication of a small-sized opportunity for the economy. Software publishing employment concentration in the Eugene-Springfield

metro is more than five times the national average. The well-being of its software businesses and their approximate 1,700 software publishing employees has statewide significance.

There are no systemized interactions between the vibrant small to mid-size software industry and the University of Oregon, Oregon State University or Lane Community College. There is lack of incentive for faculty members to encourage their best graduate students to apprentice with local businesses or see them employed locally. The economic consequences to the region and to the state are myriad. The pace of Eugene-Springfield software publishing growth is hampered by businesses conducting lengthy national job searches—this also impinges on their global competitiveness. The opportunity costs to this brain drain are even harder to quantify.

If students cannot make working connections to the industry close at-hand while living in the Eugene-Springfield metro, it may be inferred they are just as likely to eventually leave the state altogether as they continue their careers in Oregon. It should not be presumed graduates will go to the Portland metro if they do not make connections early-on while at college in Oregon.

Q3 You mentioned you plan to increase your staff level in 2014. How many staff members do you estimate adding in 2014?

Answered: 13 Skipped: 2

PCEP	Portland State University Cooperative Education Program
CTL	Center on Teaching and Learning
OSLC	Oregon Social Learning Center
RAIN	Regional Accelerator and Innovation Network
OEIB	Oregon Education Investment Board
STEM	Science Technology Engineering and Math
UI/UX	User Interface/User Experience
Unit Test	Method for testing smallest piece of any software application
T-shape individuals	Acumen in a single field combined with collaborative ability
Big Data	Data sets with sizes beyond common software tools to handle and lend themselves to inductive statistical analysis

Scope of Impact

The 1,705 employees measured in 2012 in software publishing in Lane County are a significant portion of the state total of 9,129 (Source: US Bureau of Labor Statistics). However, the influence of core competencies in computer coding affects most every tech sector in the state, or the 88,934 employees with their approximate $8.38 billion annual payroll.

As the skills of fluency in computer languages are increasingly more than a value-add but required literacy for tech employers, the entirety of the Eugene-Springfield tech industry (410 firms, 4,616 employees, and an annual payroll of $272.5 million in 2012) is affected. Business Oregon clusters such as Educational Technology and Services, Software, Creative Industries, Semiconductors and Electronic Components, and Manufacturing are all impacted by the quality of instruction and interactions with the state's computer science departments.

Unique Opportunities for Investment in Eugene-Springfield

Educational Technologies Cluster

The Eugene-Springfield region is distinguished in its social and behavioral science research. Researchers at the University of Oregon's College of Education are among the most productive and innovative in the world, and bring in more grants per-capita for their tenured faculty than any other institution of higher education in their field. A third of licensing income coming to the University of Oregon originates in College of Education research. Several of its largest research units, like the Center on Teaching and Learning, or Educational Community Supports operate significant IT and software operations. They employ

scores of technical individuals and firms to maintain their large social science databases as well as develop software application systems for school districts across the globe.

The College of Education, however, is just one of several research and behavioral science institutions in this region. Others include: Oregon Research Institute, Oregon Social Learning Center, IRIS Media, ORCAS, the International Society for Technology in Education, and the Educational Policy Improvement Center. A worker selected at random in the Eugene-Springfield area is nearly nine times more likely to hold a social science research occupation compared to national averages (Source: US Bureau of Labor Statistics Location Quotient Calculator).

Training for short-term coder workforce need will supply skills necessary to commercially apply the backend technology and transform behavioral research into education tools. A holistic approach to supporting the state's Education Technology and Services cluster, and the Eugene-Springfield region's EduTech Cluster in particular, must include both course and degree offerings for specialized data scientists and the high-wage, middle skill technicians—the computer coders—needed to build EduTech service companies.

Workforce Complements: UI/UX Expert Coders and Big Data Scientists

Another need of local software businesses is complementary requests for developing more "big data" specialists employable by both bioscience firms and large scale social science research operations (data scientists are hybrids of computer science, statistician, and engineer). These "big data" specialists will lead,

over time, to development of intellectual property and new patenting. To develop an "EduTech Cluster," development of both programmers and big data scientific specialists is useful and necessary. A strong specialization at the universities in developing these experts will lead to complementary business formation in a slew of sectors, from bioscience research to agriculture.

Eugene-based video game studios and mobile application developers request assistance in producing more workers with skills in integrated UI-UX (user interface and user experience). Supplying this workforce need will help the viability of a wide-range of future business startups. Recruitment and retention of more UI/UX expert coders in the state can provide local software and educational technology companies a superior, value additive dimension to their web products and application services. Without investments in both kinds of specialties then the unique education technology opportunities in this region cannot be fully realized. Researchers and their innovations will be more likely to find capable software service providers from contracting outside of the region and state. The chance to grow local start-ups and retain existing businesses as they increase in scale will be severely limited.

Furthermore, the existing quality of local research and social scientific production benefits immensely from regular interaction with an established software publishing community of practice. The skill of each group lends technical sophistication and expertise to the other. Continued regional and statewide pre-eminence in this field is at-stake when it comes to developing the talent pipeline into software coding professions. Integrating Lane Community College and University of Oregon career development programs with local industry will also foster the types of networking and tacit knowledge transference known to create and retain talent. More apprenticeships for young people in computer coding—a kind of "big brother, big sister" or "adopt-a-coder" through the auspices of an industry allied non-profit like Thinkersmith—is a distinct opportunity in the Eugene-Springfield region.

Industry and University Research Cooperatives and/or Regional STEM Hubs

The University of Oregon's Center for Teaching and Learning, housed in the Office of Research Innovation and Graduate Education, was recently a lead applicant

to the Oregon Education Investment Board with a Regional STEM hub funding proposal. Its partners included Lane ESD, South Lane and Bethel School Districts, OSLC, IRIS Media, Thought Cycle, Fertilab Thinkubator, Thinkersmith, UO's Office of Research Innovation and Graduate Education, and the City of Eugene. Its validating research and product piloting services were meant to leverage off existing state investments in RAIN. This proposal's partnerships are an example of collaboration between industry and the university which could generate national interest. Indeed, an Industry & University Cooperative Researchv program in educational technologies for workforce development, based at the University of Oregon, could create a special value proposition for large corporations looking to strategically invest in Research and Development.

Additional investments from either public or private sources in research centers and operations that create intersection between education and business development are opportunities to boost attention on the region and assist in recruitment of high-value talent. State investments in "Regional STEM hubs" were viewed by several businesses as one such opportunity to forge connections around workforce readiness in a partnership with this cluster, school districts, and state investments in the Regional Accelerator and Innovation Network (RAIN). Investment in unique opportunities, like this Regional STEM hub proposal and its focus on preparing young people for STEM careers in software through the creation of educational technology, is a chance to create partnerships amongst education researchers, entrepreneurial software developers, and school districts. It offers piloting opportunities for new products in the local school districts and represents an opportunity to nationally distinguish this region's strengths.

Background and Scope

Why now?

This need began to grow more than fifteen years ago. Software employment in Eugene-Springfield first grew to significance in the mid-to-late nineties, and again accelerated between 2003 and 2008. Employment totals, level during the Great Recession, are now continuing to rise again. A growing percentage of jobs available to residents in Eugene-Springfield metro now require coding skills that are not taught in the K-12 system. There is a mismatch in perception of roles between computer science programs at the University system and the business community. Computer science at the University of Oregon, more than Oregon State University, is taught as a theoretical liberal arts calling and not as an engineering, technical profession. This mission is askew with the interests of many local software companies, who are looking for ways to supporting superior workforce development programs but are less than enthusiastic for studies in theoretical or basic science investigations.

Oregon State University appears close-by on a map, yet Eugene-Springfield software publishing firms tend to have less than 100 employees and do not have the time or capacity to create extensive recruitment or training programs of their own. Physical and social distance is an obstacle. Trust and understanding of an individual's "office culture fit" takes place through face-to-face interactions and personal networks of recommendation. Lane Community College does produce employable coders, but not with regularity or frequency. Closer consultation with local employers about the most current programming needs is important if its programs are to be upgraded and new associate degrees offered. Rather than viewing these hiring practice norms as an obstacle, many software publishers would like greater postsecondary attention to the assessment and validation of not only the skills, but the person.

New Skills or a Capacity Gap?

There is a capacity gap in postsecondary in the South Willamette Valley. Although funding decisions are often linked to employment department projections with "minimum educational attainment,"vi software publisher employers themselves often place little real emphasis on degrees, or even academic disciplines (geography majors may have greater aptitude than someone with bachelors in computer science). Greater credence is given to demonstrations of technical aptitude than bachelor's or associate's certifications. Many believe some of the skills listed below may be provided by Lane Community College as well as the University of Oregon.

Required Competencies

Graduates of programs at postsecondary institutions in the Eugene-Springfield area must be able to: code a sample project in Java, Python, or Javascript over a specified time period; have experience with version control (like GitHub); and be capable of debugging pre-

written code. Qualified graduates must have experience coding in more than one language (and be capable of switching between the languages). To become competitive job applicants, students must know how to name and structure code for testing and maintainability, and know how to write a good unit test that covers more than the "golden path" of use.

If they are to be employable by local industry, postsecondary must do more to ensure graduates know how to manage memory. This means understanding how excessive creation and mismanagement of streams and file handle objects can impair a production environment. Students in computer science programs and courses must be instructed in the balance and purpose of quick mock-ups and in lasting quality. Students need knowledge of how to switch between layers of abstraction and gain greater exposure to IT. Integrated UI/UX instruction and graphic design coding is needed for many of the entry level engineering positions in web/mobile application design and the games industry today.

Graduates must have a portfolio of real world projects— preferably on "products that shipped"—to help local employers assess their core competencies. Graduates must have excellent experience collaborating on real-world projects; specifically, learning how to divide tasks between team members, and then getting all their separate work items to piece together. This will give graduates a sense of the needs of project management. Being able to vocally demonstrate understanding and relate walking through an algorithm is also part of learning effective team work and essential to becoming employable.

Beyond these minimums, employers would like students to learn more about what it means to work with clients to elicit a deeper understanding of their business requirements; gain the ability to estimate the amount of time to complete a coding job; understand some of the inner workings of algorithms; write their own hash tables in languages of their choice; develop an understanding how to use both front-end and back-end technologies; and to understand project management and quality assurance as part of the business of software publishing.

T-Shaped Individuals in Software Development

Firms interested in developing long-term specialization in the university

Q1 Which job categories do you anticipate being the most difficult to fill in 2014?

Answered: 15   Skipped: 0
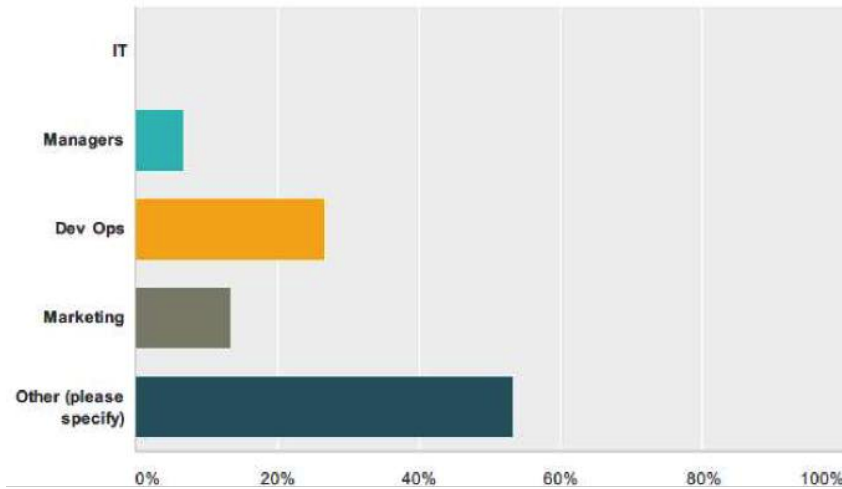
for "big data scientists" are also looking for people with bachelors in computer science, masters in data sciences or statistics, and PhD's in data sciences, statistics, and machine learning. Foundational knowledge on web scale technologies is more needed than the specifics of any one technology. Developing over the long-term a specialization in big data research will work well with the investments being made in technology commercialization and developer/IT technical talent for local workforce development.

Within the "other" category of TAO business surveys the requests for "T-Shaped" individuals became more obvious. Senior level programmers, web developers, testers, UI/UX designers, information security experts, and front or back-end coders are reportedly the most difficulty job categories to fill in Eugene-Springfield. Programmers with additional marketing, sales, customer elicitation, and training capabilities are increasingly in demand and highly valuable. Students also need to be better prepared to communicate their specific technical skills in their resumes and in interviews.

How broad is the need, and how predictable?

The past year has seen the creation of multiple industry technical advisory boards by the several school districts and the University to respond to the needs of the tech sector—of which, software publishing is the largest participant. While this has created many reports and documents of notes covering the specific educational needs of this local industry, the problem is more systemic and broad.

Although software publishers is the sector most directly affected in Eugene-Springfield, the STEM skill requirements for coders cuts across

a wide range of professional, scientific, and technical occupations.Computer language fluency is projected to become increasingly important to other, traditionally blue-collar sectors—especially in the fields of advanced manufacturers. Already, beyond just semiconductors or electronic components, the wood products and metals industry need more operators proficient in multiple computer languages.

Moreover, as the pace of collection and volume of information in all facets of life are accelerating, the commercial potential and value of having skilled analytics persons will increase. Therefore, big data scientists with hybrid statistician and coder skills will be needed to fill roles in a variety of fields and industries, too.

Q4 In which of the following areas do you see your staff increasing in 2014? (select all that apply)

Answered: 13   Skipped: 2
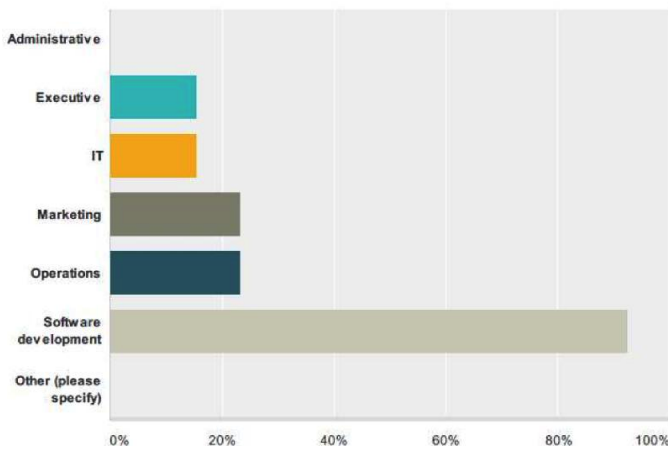
Technology unpredictability will be an ever-constant challenge to workforce development, which points to the need for more apprenticeship models in

education. To create a sustainable model where employer requirements (which change more rapidly in the production of computer software), feedback loops need to be built into university departments and into models of instruction. The feedback loops may either be formal, through close industry participation on boards overseeing curriculum development, or informal, through the creation of "professors of practice" positions at postsecondary institutions or flexible co-laboratories with visiting instructors from local businesses.

Who is serving this need now?

Within the state, the Oregon Institute of Technology is often cited by local software publishers as having the greatest academic rigor and as producing the most employable graduates with the requisite practical experience. It is most frequently described as the institution most up-to-date with the current needs of software publishing employers. Oregon State University is also recognized as responding better to the needs of software publishers by bringing an engineering perspective to its instruction. However, Oregon State University is perceived as not only geographically distant from employers in Eugene-Springfield, but socially remote, too.

The innovation ecosystem in the South Willamette Valley would be greatly enhanced by the presence of engineering education programs, like offered by the Oregon Institute of Technology, working in partnership with the local postsecondary. The collision of social science, liberal arts, businesses, and engineering talent within cities are well-known to catalyze agglomerative economies responsible for metropolitan growth and spurring innovation. Absent this higher level of engineering talent in the Eugene-Springfield metro, investments in incubation and technology commercialization are hindered from reaching the best outcomes (large scale, successful companies).

The increased presence of OIT education programming in the South Willamette Valley could both balance and strengthen the overall health of the entrepreneurial and tech business climate in the state's second largest metropolitan region. OIT has a mission strictly attuned to servicing the needs of this state's tech industry. They could supply a role in workforce development missing in this critical region of the state's ecosystem (if they were located in greater proximity to this area's businesses).

What are the consequences if the need goes unfilled?

If the need goes unfilled, the short-term consequence will be frustration by many of the top tech employers in this region and a reappraisal of their firm's location compared to larger labor markets with more amenities. The University of Oregon computer science department's national rankings will suffer if students are not afforded more opportunities to practice on "products that ship." The medium-term consequence will be felt most strongly by the local communities. Graduates of Oregon postsecondary institutions not at the top of their classes will find their skills insufficient for local employment. They will either settle for less-paying positions locally, or decide to leave the region to find work. This will both exacerbate the wage gap between Eugene-Springfield and Portland and undermine investments in other economic development competitiveness initiatives.

The long-term consequence, in the next five to ten years, is to risk the competitiveness of the region and the state, as big employers and corporations recognize the shortcomings of the region's postsecondary education in a critical field of high-tech. This will impede competitiveness in not just the bevy of Business Oregon clusters aforementioned, but will reduce the creative capacity and integrity of the state's entire innovation ecosystem.

Recommendations

There are several recommendations to increase measures of employable competencies and the level of assessment of the person. These range the gamut from short-term curriculum changes to longer-term creation of new programmatic offerings or industry-education cooperatives.

A. The University of Oregon may be able to pilot a Graduate Internship Program for Junior Year Interns with a following Fall externship. Other considerations include hiring more "professors of practice" to help meet the short-term workforce needs of industry. Another opportunity is the "4+1" model of assessment (four years of undergraduate plus one year of graduate education and a year of paid internship at a regional business) from Oregon's Materials Sciences Institute relies heavily on trust in the screening abilities of an individual graduate school internship coordinator at CAMCOR. This model of instruction has many benefits, including extensive, project-based, practical experience apprenticing for advanced technology companies. However, the sustainability of the model rests in large part on the trust in the individual coordinator and the recommendations the person makes to companies. It works as part and parcel with one of the most highly regarded departments in the university system.

Therefore, it is recommended additional methods of facilitated

mentoring are included in the South Willamette Valley's postsecondary offerings. Extending the existing undergraduate experience to include more externships and project-based learning could redress some of the basic, core skill development shortcomings of current programs. Furthermore, it incentivizes continuous interaction and creates points for feedback between industry and educators. An example program is the PSU/PDX PCEP, which has many features of cooperative work with regional companies.Lane Community College is one likely target for establishing such a model cooperative because of its greater flexibility in designing curriculums and creating new degree or certification offerings.

B.   Another recommendation is the creation of postsecondary "digital badges," or ways of recording how students have practiced and adequately demonstrated particular technical or soft skills employers most care about. Education institutions making and monitoring digital badges for the completion of milestones could become more reliable than reliance on student resumes, and makes educators accountable for students gaining core skill experiences. The effectiveness and monitoring of digital badges is potentially accomplished by University of Oregon's College of Education (possibly by the research unit "Center on Teaching and Learning"). The Oregon Education Investment Board is currently working with the state legislature to create federated longitudinal databases for all Oregon students, which would complement the creation of these kinds of digital badges (and create additional "big data" business development opportunities).

C.   When considering new programs, like the PSU/PDX PCEP, educators should also consider cooperating around building a place like a "co-laboratory" as supplementary offering to their existing set of degree programs. A collaborative learning space as an element of a new program can create independence in mission, flexibility to emerging employer needs, and a locus for piloting novel approaches to STEM instruction. The co-laboratory could be conceived either as experiential learning for students at the University of Oregon as part of RAIN, or as an extension of Lane Community College's Computer Simulation and Game Development programs. Ideally, it could function as a connection between the two within RAIN's construct of an "innovation network." Facilitated mentoring, a place to network in physical proximity to downtown software companies, and opportunities to learn critical entry level skills would be crucial elements.

Important aspects of the recommendation for a new collaborative working environment, also known as the "co-laboratory," are: a) exclusivity (the program could assess and filter star, talented candidates without reference to formal enrollment in academic program); b) unit testing "boot camp" style instruction; and c) skilled project management and guidance by an industry trusted instructor. An indication of its success will come from industry feeling the service delivery from postsecondary generates enough value for them to continually contribute to the project manager position of the computer co-laboratory on an on-going basis.

An idealized co-laboratory should include offering quality assurance or web development services to a range of start-ups and small businesses. Teamwork, overseen by a professional project manager on real world assignments, could also train students in the process of moving code into something applicable, expose them to the most up-to-date coding and projects in the area, and instill many critical soft skills. Training students to write unit test code and utilize automated testing suite software would make them instantly employable to many firms requiring affordable, effective quality assurance work. The automated testing suites would prevent businesses from harm, while still giving students a valuable experience. If the costs of review and oversight could be shared

with a public instructor/project manager this would offer several advantages over internships totally reliant on the direct oversight of small businesses.

Features of dedicated computer lab space, like open off-hours and membership accessible to multiple postsecondary student bodies, would better facilitate local employers looking to mentor students at times that fit their own work schedules. A program and late-hour computer lab, housed outside of any particular degree or college, would also increase access to skill development to a wider population and increases labor pool size. It would open continuing education offerings for those looking to become T-shaped individuals themselves (like code certifications for social scientists or business administrators, etc.).

Informal meeting space attached to the lab could also encourage the kind of efficient, personal networking and one-on-one, face-to-face interaction companies desire to cement trust and establish an individual's overall fit to their business. This is preferable given the burdens small firms face when hiring very green new employees or conventional internships. (Re-location of Lane Community College computer science from South Eugene to the downtown Eugene campus would also be beneficial for fostering interaction with local businesses).

Direct investment in the instructor position and oversight by an industry board will incent their continuing participation in updating curriculums. Plus, less emphasis on "coursework," and more on project learning assignments, will create greater exposure to the latest workplace skill needs updated in real time rather than waiting for quarterly or annual reviews. It could create more of the apprenticeship-type experiences, but require less of small-sized firms in organizing. Assessing performance would require following co-laboratory student members post-graduation from projects or programs (i.e. how many remain employed in the field in the state).

Category	Reported Metrics
Graduate Internship Program	Employer reviews of interns
	Intern reports on their internships
	Number of intern placements per year
Undergraduate Externships	Number of projects on "products that ship" per year
	Amount of Investment
	Department Progress Updates
	Employer evaluations
	Matriculated student placement at local companies
"4+1" Graduate Education in Computer Science	Updates to undergraduate curriculum reflecting practical needs
	Enrollment numbers in collaborative courses
	National rankings of UO Computer Science department
	Graduate student pedagogy (papers, presentations, dissertations)
Digital Badges	Creation of longitudinal databases
	Surveys of percentage of industry utilizing for placement
	Student surveys of participation and satisfaction
PCEP Model at LCC	Number of participating businesses
	Amount of private sector investment
	Number of student work projects started/successfully completed
Co-Laboratory	Utilization by small and mid-size business to establish connections
	Use by number of students from non-traditional computer science backgrounds
	Surveyed satisfaction with product by small-businesses, entrepreneurs
Employment	Number of graduates finding employment in Lane County
	Number of graduates finding employment nationally
	Industry reports on increase in the of quality applicants from local postsecondary
Retention	Enrollments in software engineering courses Comparison of enrollments before and after Number of BS and MS power graduates per year

Engineering & Prototyping of Interconnected Devices

Abstract

Billions of ordinary things are being instrumented with sensors, actuators, and the ability to communicate. This enables communications between devices and the Internet for both remote monitoring and control. This has applications in many economic sectors including the consumer market, industrial monitoring and control, and healthcare to name but a few. The application domains can be broadly divided into 1) information and analysis and 2) automation and control.

The economic impact of this so-called Internet of Things is expected to eclipse the recent technological booms of the PC market in the 80s, the dot-com growth in the 90s, and smart devices in the 2000s. The sales could be as high as $9 trillion by 2020 with over 30 billion autonomous devices connected to the internet. The number of ordinary things connected to the internet may be as much as 10 times the total number of internet hosts, including smart phones, tablets, and laptops, that are connected today.

Oregon is well positioned to take advantage of this opportunity with strengths in semiconductor and MEMS manufacturing, embedded systems, contract manufacturing, and a growing infrastructure and community of technology startups.

However, Oregon has two urgent industry needs to take advantage of this opportunity..

First, our engineering workforce does not currently have enough team proficiency to design low-power interconnected devices suitable for practical

applications. In order to meet the requirements that will enable real-world applications, useful devices and systems must be low powered, wireless, compact, robust, and virtually autonomous. Moreover, these devices and systems must provide critical functions including sensing, signal processing, data storage, and data management.

Second, although Oregon has extensive manufacturing companies and facilities, we currently lack a facility with engineering staff to support prototyping of interconnected devices required to enable rapid design iterations that are necessary to develop stable and robust manufacturing processes

In short, Oregon has an urgent need for engineers who can lead or contribute to engineering teams developing interconnected devices and for a facility to support rapid prototyping that bridge the gap between concept and manufacturing.

Impact

What is industry unable to do, or do well, at this time as a consequence of a critical, urgent, unfilled workforce need?

The shortage of talent and the absence of cost-effective prototyping. has created a situation that makes Oregon industry less competitive with other states and results in lost opportunities.

What is the scope of the industry sector(s) affected?

Oregon has four industry sectors affected by this need. In the semiconductor manufacturing sector Intel is continuing to invest heavily in developing the infrastructure and capabilities required to produce ultra-low power systems-on-chips (SoC) necessary for autonomous and interconnected devices. Smaller Oregon-based companies such as Maxim and TriQuint are also affected. Second, we have companies that design and develop embedded systems, but currently do not produce interconnected devices. Third, Portland is host to a growing ecosystem of entrepreneurs, investors, and startup companies. This cluster generates

concepts and can evaluate the soundness of business models, but lacks the resources to purchase prototyping equipment and services. Fourth, we also have a cluster of companies capable of manufacturing these devices. Growth in interconnected devices could fuel substantial growth of this sector.

Does Oregon have a unique opportunity?

We already have a strong group of local companies who can support all stages of manufacturing from small to large scale. Oregon also has a strength in IC design and manufacturing. Notably, Intel has made a substantial investment in the development of integrated circuits and infrastructure to support this area. Furthermore, Oregon companies like Tektronix and Rhode & Schwarz are developing test equipment suitable for characterizing low-power wireless devices. Other large companies located outside of Oregon have also invested heavily in this new area including Oracle, Cisco, Qualcomm, IBM, Google, and GE to name a few.

Participants?

A list of supporters and contributors to this document is included on the first page. Letters of support are also included.

Background and Scope

Why is the need emerging now?

Over the last decade, there has been remarkable progress in the development of the new technologies that form the foundation of the Internet of Things (IoT). Compact, wireless, and low power systems capable of deriving power from the environment are enabling autonomous operation for extended periods of time. Advances in signal processing, sensing, computational strength, networking, and cloud-based connectivity are enabling systems that are aware, pervasive and ubiquitous. New sensors that offer remarkable sensitivity are emerging that provide real-time information about the environment, crowd behavior, personal health, and many other state variables.

Consequently, the demand for scientists, engineers and technologists capable of inventing and designing these embedded systems and for a regional resource to rapidly prototype these systems are likely to be long lasting.

Other metropolitan regions have established centers or nonprofit organizations to address this need. Examples include Makerhaus and Metric Create: Space in Seattle. Both provide tools, space, workshops, and knowledge to support the local "maker movement." However, neither of these facilities focuses on interconnected devices, enables startups, or is integrated with academic engineering degree programs.

Does this need require new skills, or is it just a capacity gap?

Portland State University offers academic programs focused on embedded systems at both the undergraduate and graduate level. Oregon public universities collectively have strengths in many of the technical areas that are required to produce interconnected devices for the many market opportunities. These include areas such as security, embedded systems design, privacy, instrumentation, low power communications, sensing, machine learning, signal processing, industrial design, statistics, data management, analytics, and more. Arguably, Oregon university programs should be stronger in some areas such as design-for-manufacturing, , user experience, environmental robustness and ruggedness , reliability, automation, synchronization, fault tolerance, energy harvesting, and business model validation.

While the curriculum for our programs prepares engineers well with the knowledge, theory, and skills in each of these areas, Oregon is does not have a centralized facility and organization that prepares our new college graduates to work on interdisciplinary teams involved in the design and production of fully functional interconnected devices and autonomous systems.

How broad is the need?

In addition to industrial partners, Oregon universities can also help overcome some of the key barriers to widespread deployment of interconnected devices. From a software and computational perspective, barriers include reliable and strong data security and privacy, big data management and analysis, and computationally efficient analytics that transform data into actionable information. From a hardware perspective, challenges include the design and development of low-power circuits energy harvesting technology, real-time computational processing, and pervasive networking. Moreover, these new technologies must be manufactured and deployed using green and sustainable practices.. There are also many challenges associated with the development of intelligent software systems that can rapidly adapt to different environmental conditions and transient events. Rather than producing embedded systems that only respond to their own sensors, these systems must collectively provide the best user experience. For example, if a thermostat has an infrared sensor used to determine the presence of people in the room, it should be able to communicate and leverage information that is being acquired in neighboring environments. The motion sensor should also be able to take advantage of the IR sensor in the thermostat for detecting people. Developing this technology in such a flexible manner while providing appropriate safeguards for security and privacy requires engineers that are capable of developing novel software solutions using programming methods that are very different than conventional methods and approaches.

How predictable is the need?

Many companies, professional organizations (such as the IEEE), and venture capitalists are investing in technologies, solutions and services that will provide the network and environmental infrastructure that will support vast networks of interconnected devices and sensing systems. Furthermore, the exponential growth in mobile technologies such as smart phones, tablets and wearables is placing even more demand to develop and provide technologies offering pervasive

and ubiquitous interconnectivity. The need for scientists, technologists and engineers that possess the right skills and know-how to realize the vision of the IoT is a clear and urgent need.

Who is serving this need now?

Currently, Oregon engineers are primarily teaching themselves how to develop these systems. Academic programs that focus on embedded systems and related areas provide much of the fundamental background necessary to design these devices. However, these programs only partially addresses the need. And while we have some facilities in the Portland region that support the "maker-movement" such as including OMSI, ADX, and BrainSilo there is a significant need for additional resources. Finally, Oregon's universities do have some prototyping facilities, but none of these provide engineering services or are dedicated to teams of engineers that produce interconnected devices.

What are the consequences if the need goes unfilled?

The growth of interconnected devices will occur rapidly. If Oregon technology companies, new and established, are to be competitive, they will need access to new college graduates with this knowledge and these skills. Leaving this need unmet will reduce the likelihood that Oregon can become a leader or grow its economy. Moreover, leaving this need unmet may also impede initiatives in cybersecurity and big data, both of which are integrated with interconnected devices and are ETIC initiatives identified as industry needs.

Recommendations

What are the broad areas of capability or job responsibilities that need to be filled?

- Companies are not consistent in the use of job titles to describe their needs. For example, essentially the same job may have the job titles of "Embedded software engineer," "Systems engineer," or even "Lead Internet of Things Engineer."
- Based on current job descriptions, the following proficiencies are expected:
- Master's or PhD in Computer Science, Computer Engineering, Electrical Engineering, Mechanical Engineering, or related
- Experience with the design and development of distributed systems

- Experience with embedded programming. C/C++ and Java are requested the most often.
- Experience with real-time operating systems (RTOS)
- Experience with Linux
- Familiar with industrial control systems
- Understanding of security challenges of distributed systems
- Experience with security methods (e.g., encryption, authentication, access control, trust, publish/ subscribe security)
- Experience with large data management including cloud computing
- Experience working in teams with Agile methodologies
- Signal processing algorithm development
- Experience with WiFi, Zigbee, Bluetooth, BLE, RFID
- NFC
- Wireless LWAN capabilities as well as 4G/LTE/etc.

Who is likely to use the system?

New college graduates and working engineers who wish to upgrade their skills are likely to use the educational programs.

How will we know if the need is being met?

The clearest sign that the universities have educational programs that are addressing the needs of Oregon companies is that Oregon companies are hiring their graduates. We will also see a growth in the "maker-movement" within the Portland region as it relates to connected and intelligent endpoint systems and products. Other indicators of a successful program are university-industry partnerships and other engagements such as internships and industry-sponsored projects. We should also see a growth of investments in Oregon startups and incubator / angel funded products. If we succeed, larger companies and investors will start to think of Portland as the natural choice for large investments.

How do you recommend setting up the education delivery system to best respond to unexpected or emerging needs?

The single most important qualification typically lacking in new college graduates is experience. We recommend that educational programs provide students with hands-on experience working on engineering teams to develop working prototypes with industry-grade prototyping equipment.

Electric Power Industry

Abstract

Examination of engineering employment needs within Oregon's electric power industry shows two concurrent trends: the workforce is on the verge of a major contraction while simultaneously experiencing escalating employee demand. This is a result of large-scale retirements, paired with operational expansions due to renewable portfolio standards, updates to aging infrastructure, enlargement of regulatory compliance and increasing power requirements on the bulk electric grid. Within Oregon, the power industry is represented by a diverse array of over 100 companies, the Portland Power Pool, all of whom are subject to this employment trend. Oregon's power engineering programs currently do not have the ability to keep pace with projected industry employment needs.

Impact

The Pacific Northwest hosts a large and diverse power industry, with a number of major industry contributors located in Portland, OR. This needs statement addresses the Portland Power Pool (PPP), which consists of local utilities, consultancies, federal entities, developers, manufacturers and engineering service firms, as well as companies within the high-tech cluster moving into the smart grid domain (Appendix A). The PPP represents a sizable fraction of the regional economy.

Investment in new generation and transmission, innovations in communications and IT, and rapidly-decreasing prices for renewable resources are all contributing to the industry's growth. These combined factors, along with a comparatively rare abundance of natural hydro and wind generation resources, create a unique advantage for the Pacific Northwest.

Furthermore, low power rates attract business in manufacturing and high technology industries, thus creating a stronger and more diverse state economy. If developed with thoughtful intent, the region stands to gain international recognition for innovative and sound practices in power engineering, thereby setting a global precedent and becoming a region of excellence in power engineering. This potential, though, can only be achieved if it is underwritten by a wide and talented pool of local power engineers.

The Electric Power Industry's Workforce Needs

The impending large-scale retirement of power engineers has long been forecast.1,2 Several recent publications echo these projections for nation-wide, large-scale retirements from the power industry. A 2011 survey by the Center for Energy Workforce Development (CEWD) projects a 38% turnover of engineers to occur between 2010 and 2015, with an additional 15% turnover in the ensuing five years, amounting to a national need for nearly 15,000 replacements by 2020. Regionally, three employers of power engineers, Portland General Electric (PGE), PacifiCorp and the Bonneville Power Administration (BPA), project short-term, 2015-2020, retirement of 52% of their current workforce, amounting to around 500 engineers (Table 1).6 In addition, technological, regulatory and political changes are resulting in increased investment in power systems planning and capital investment, further driving the demand for power engineers.

In order for Oregon to meet its renewable portfolio standard, maintain environmental quality, keep customer rates low, move towards greater energy independence and meet increasing electricity demand, an additional 1,300 or so new power engineering positions may be needed by 2020. The current graduation rates of engineering students from Oregon's universities are insufficient; only around 490 engineering students versed in power engineering may graduate by 2020. Oregon's power engineering education programs will provide only slightly more than one-third of the demand for power engineers over the 2013-2020 period;

creating a talent deficiency for meeting the needs of industry, government mandates, and the Governor's Ten Year Energy Action Plan.

Oregon's Unique Opportunity

Challenges of meeting RPS requirements, FERC Orders, PUC mandates and carbon limits are issues of national concern; every state is under pressure to comply with mandates of some form or another. This creates a compelling interstate competition opportunity, because the first state to develop the educated talent to address these issues will become the national leader in power engineering expertise. This carries very large economic implications for that state, as others look to them for answers and ideas by hiring power engineers from consultancies based in that lead state. New business opportunities will compound, further increasing that state's power engineering expertise.

Oregon has a unique advantage in seizing this lead role because of the Portland Power Pool, which consists of over two dozen consultancies that serve national and international clients. As large amounts of highly skilled engineers are produced, these PPP companies will hire Oregon graduates, allowing regional businesses to grow and become stronger. Other states around the nation will outsource their compliance and engineering work to Oregon companies and the region will experience an economic snowball effect. Oregon will thus develop a self-sustaining cycle between industry and university sectors, becoming economically robust and recognized for excellence in power engineering careers and education.

Oregon's Existing Electric Power Engineering Education Programs

Three Oregon universities have educational programs in power engineering. Degree offerings relating to power engineering at each university are itemized below.

- Portland State University: Electrical & Computer Engineering, MS ECE and BS EE programs with power engineering foci

- Oregon State University: MS and BS ECE programs with power engineering foci; Wallace Energy Systems & Renewables Facility; Oregon State University, Cascades: Energy Systems Engineering

- Oregon Institute of Technology: BS and MS in Renewable Energy Engineering

Definitions

APS   Alternative Energy Portfolio Standard
BPA   Bonneville Power Administration
FERC   Federal Energy Regulatory Commission
IEC   International Electrotechnical Commission
IEEE   Institute for Electrical & Electronics Engineers
NERC   North American Electric Reliability Corporation
PGE   Portland General Electric
PPP   The Portland Power Pool
PUC   Public Utility Commission
RPS   Renewable Portfolio Standard

Background and Scope

Provide background to understand the breadth, depth and longevity of the need to weigh investment size and duration.

The Emerging Need for Electric Power Engineers

Putting Table 1 in real terms, there will be approximately 390-510 power engineer retirees between PGE, BPA and PacifiCorp by 2020. Graduation rates from the Oregon Institute of Technology (OIT), Portland State University (PSU) and Oregon State University (OSU) power engineering programs from prior years indicate that Oregon could produce an estimated 4070 new engineers annually. These graduation rates would provide the industry with just 280-490 new power engineers by 2020. Consequently, there is a projected deficit in maintaining engineering staffing levels at just PGE, BPA and PacifCorp. This shortfall does not even consider the employment needs of the wider Portland Power Pool, nor does it account for forecasted power engineering employment growth due to Renewable Portfolio Standards (RPS) compliance, investment in energy efficiency and smart grid technologies, expansion of the electric vehicle infrastructure, impending carbon restrictions, or upgrades and expansion of generation, transmission and distribution assets. All of these categories will require employees to develop new skill sets. It is also important to note that this industry turn-over replaces knowledgeable veterans with entry-level engineers, who take up to fifteen years to fully professionalize.

Workforce Needs Driven by Technology Changes

Ongoing adoption of new power systems technologies, loosely bundled under the banner of 'smart grid', is allowing for greater utilization of existing capital infrastructure. These technologies include wide-scale deployment of data-gather devices such as advanced

metering infrastructure (AMI) and synchrophasors; SiC-based power switching devices and novel control algorithms applicable to a diverse array of power conditioning systems; reliable and cost-effective chemical battery storage technologies; and, rapid adoption of highly-networked digital relaying schema. Consolidation of open power systems communications standards, such as DNP3 and IEC 61850, and revision of anti-island schemes such as IEEE 1547.8, are spurring further innovation. These technological advances are driven by the need to upgrade an aging grid, particularly in light of large-scale adoption of non-dispatchable generating resources such as wind and solar. Consequently, demand for power engineers, particularly those versed in the fundamentals of these new technologies, is on the rise.

Workforce Needs driven by Legislative, PUC and NERC/FERC Mandates

The 2007 enactment of Senate Bill 838 began Oregon's Renewable Portfolio Standards, which require that electric power utilities supply yearly increasing percentages of total power from renewable resources. Regionally, Oregon Public Utility Commission (PUC) mandates such as UM 1573 for energy efficiency power purchase agreements and UM 1460 for smart grid, as well as Oregon legislation like ORS 757.370 mandating solar capacity and ORS 469A introducing Oregon's

Renewable Portfolio Standards, are placing pressure on the regional power industry to incorporate new technologies and implement renewable generation. Nationally, recent FERC Orders are providing regulatory framework for wholesale market interactions, demand response and ancillary service compensation, transmission planning and cost allocation of transmission infrastructure.

Concurrently, twenty-three other U.S. states have passed RPS legislation or Alternative Energy Portfolio Standards (APS), which are spurring investment in technologies such as wind, solar and geothermal generation; carbon-capture & storage technology; and, the transmission and distribution infrastructure required to support these new resources.[18] The extra engineering work required by these mandates is increasing the demand for additional power engineers and the effects of these mandates have already become apparent. Notably, the number of electrical engineers in the U.S. power industry has experienced a 43.8% growth rate in the span between 2004 and 2012, an unprecedented excess over the DOE-predicted 8.1% growth over the 2004-2014 period.

Workforce Needs driven by Carbon Limitations

The growing need for power engineers is exacerbated by increasingly stringent worldwide carbon restrictions. A study conducted by Greenpeace International and the European Renewable Energy Council predicted the creation of 300,000 extra jobs in the U.S. energy sector between 2010-2020, in response to limiting carbon emissions. According to the Bureau of Labor Statistics (BLS), 3.7% of current energy sector employees in the U.S. are electrical engineers.[20] This forecasts an additional 11,100 electric power engineering jobs for carbon restrictions alone in the U.S. by 2020. However, this figure does not account for engineering growth rates, or the non-utility and other-discipline engineers working in the power industry. The actual number for general power engineering job creation would reflect a much more expansive growth.

Projected workforce expansion is not solely attributable to the carbon restriction economy; but also to impending demands from industrial upgrades. It is important to remember that, regardless of future carbon market effects, the U.S. power industry will require major overhauls to equipment that is presently decades past its designed lifetime. This being said, it is probable

that power engineering workforce demands will be exacerbated by carbon regulation in the United States. Furthermore, many carbon motives in the U.S. are driven by international competition in progressive environmental measures. The risk associated with future carbon restrictions is leading to investment apprehension in new coal generation resources, thereby forcing system upgrades to target growth in renewable energy and the smart grid.

Recommendations

Outline specific recommendations for the content and the format for delivery of higher education offerings to meet the workforce needs.

Addressing the Need for Electric Power Engineers

It is abundantly clear that Oregon would benefit greatly from innovation in electric power engineering education. This comes at a time of projected power engineer shortages, along with dismal university retention rates and delayed professional development of entry-level power engineers. To achieve tangible results, we intend to tie together the power engineering programs across Oregon, provide experiential learning environments, and promote internship opportunities through innovative industry-university partnerships. We believe that this will enhance the educational experience for our students. We recommend leveraging the existing power engineering programs offered at Oregon Tech, PSU and OSU to create industry-focused learning environments, the Oregon Power Engineering Education Project. In combining efforts, the three institutions can each refine their unique strengths, thus creating a more comprehensive Oregon power engineering educational framework and garnering a stronger reputation. We recommend addressing the following four main pillars through ETIC-funded initiatives.

Pillar 1: Internship Program

We recommend developing an internship program, in partnership with industry, to provide internships for power-related B.S.-level engineering students at PSU, OSU and Oregon Tech. Internship opportunities should be coordinated through partnerships with companies of the PPP.

Currently, two avenues for internships are available for students, the well-established and highly-regarded MECOP program, and the go-it-alone path whereby students find an internship independently. We intend to develop a third, which will direct the pool of power engineering students from PSU, OSU and Oregon Tech towards internship opportunities with companies of the PPP. The program will involve soliciting internship opportunities from companies, helping students with cover letter, CV and interview skills, management of internship issues, and follow-up reporting and feedback.

Pillar 2: Engineering Pedagogy

We recommend development of compelling and challenging engineering courses that will prepare graduates for careers in the power industry. As such, the Oregon Power Engineering Education Project should feature a strong focus on engineering pedagogy. We recommend:

- Diversifying and aligning course offerings, as much as reasonably possible
- Emphasizing project-centric coursework
- Improving Engineering Pedagogy
- Adopting and developing new engineering pedagogy practices
- Developing feedback mechanisms directed at improving pedagogy
- Investing in the next generation of power engineering educators

Course Alignment & Diversification

As the consortium between PSU, OSU and Oregon Tech evolves, so should the diversification of course offerings. We recommend the schools leverage the combined faculty expertise to improve the depth of our course offerings, particularly for the two Portland-area schools, Oregon Tech and PSU. Initial focus should be given to 500-level courses, with the objective of broadening the course options available to students. The schools should share best-practices, and encourage collaboration between faculty members at the three universities. These efforts will leverage each institution's specialties within the power domain:

PSU - Power systems protection; power systems operations; smart grid; power systems design

OSU - Power electronics, smart grid; electrical machines & drives; excellence in funded research, particularly wave energy generation

Oregon Tech - Renewable energy generation; energy storage; grid integration of renewables; electrical power systems; engineering education pedagogy

Engineering Pedagogy

With an eye toward promoting long-term investment in power engineering pedagogy, we recommend funding three graduate student positions, one at each university, which will promote innovative research on engineering pedagogy. The graduate students should receive multi-year funding to conduct studies on teaching methods, assessment, retention and other engineering education topics; these funds shall not be used to support graders or TAs whose research is not focused on engineering pedagogy. These graduate students shall provide faculty with the means by which they can adopt new teaching practices or assess their own innovative methods. These students should play a significant role in the teaching laboratories and capstone projects. Results shall be documented via journal publications, conference presentations, thesis and dissertations. These positions shall not only promote innovation within our power engineering programs, but also produce the future expert teaching and advising faculty, which are currently in short supply.

Pillar 3: Collaborative Undergraduate Projects

We recommend the schools provide all B.S.-level power engineering students with the opportunity to pursue a power-related capstone/senior project. To facilitate the projects, a funding mechanism shall be created for these power-related capstone/senior projects so as to provide teams with funding that they can apply towards their projects.

We recommend the creation of a second funding structure, one that encourages independent and innovative student projects such as an Innovation Investment program with two phases of funding. The program will hand out a number of Phase I grants and Phase II grants per year, with the Phase II grants given to a subset of the previous years' cohort of Phase I grantees. The purpose of this program shall be to provide students with a means by which they can pursue project ideas outside of the more structured capstone/senior project mechanisms, and to instill in students the

idea that innovation is rewarded and has a meaningful place within the power industry.

Providing funding for capstone/senior projects and the innovative projects will attract a large and passionate student base to the power engineering programs at PSU, OSU and Oregon Tech.

Pillar 4: Power Engineering Project Centers

We recommend the development of two project centers at PSU and OSU, and to further develop the existing project center at OIT in Wilsonville. The objective of these centers shall be to provide students with space, tools and equipment needed for them to implement power-related engineering projects. These centers shall promote a spirit of entrepreneurialism and spur collaborative innovation. Within them, the schools could host industry-sponsored projects, student-initiated projects as well as student-run start-up companies.

The pedagogical purpose for the facilities is to restructure the undergraduate engineering education experience by exposing students to more open-ended engineering problems, fostering teamwork and promoting innovation, all to generate student excitement in electric power engineering. Experience- and research-oriented learning is proven to increase undergraduate retention levels in STEM. Students are encouraged to take ownership over their education through opportunities afforded at these facilities.

Measuring Outcomes

The pedagogical research students at each school will be responsible for yearly data collection and reporting of success and progression metrics. Proposed metrics for reporting are listed in Table 2.

Table 2

Category	Reported Metrics
Intern Program	Employer reviews of interns
	Intern reports on internships
	Number of intern placements per year
Engineering	Enrollment numbers in collaborative 400/500 level courses
Pedagogy	Graduate student pedagogy
	Pedagogy-related papers
	Pedagogy-related presentations
	MS thesis and PhD dissertations
Collaborative	Number of power-related projects per year
Undergraduate	Number of inter-institutional projects per year
Projects	Amount of Phase I investment
	Amount of Phase II investment
	Progress of Phase I projects
	Progress of Phase II projects
Employment	Number of graduates finding employment within the Portland Power Pool Number of graduates finding employment within the national power industry
Retention	Enrollments in power-related engineering courses
	Comparison of enrollments in 1st power course to last power
	Number of BS and MS power graduates per year
	Ratio of power cohort sizes to overall ECE/REE student cohort sizes

Conclusion

Oregon's electric power industry currently faces a challenge and an opportunity, the outcomes of which both depend critically on the availability of engineering talent. First, the long-anticipated large-scale retirement of power engineers is now underway, resulting in significant turn-over and threatening the loss of critical institutional knowledge at BPA and the regional utilities. Second, a strong regional power engineering industry has been growing in significance; as the talent pools within utilities nationwide dry up due to retirements, many in-house utility engineering positions are being filled by out-of-house talent from consultancies and developers. Across the nation, investments in energy infrastructure, expansion of regulatory compliance, and mandates for smart grid development are all driving demand for engineering talent. Many of the companies that provide these power engineering services have chosen to locate in Portland, Oregon.

The 100-plus companies of the Portland Power Pool represent a significant strategic economic asset for the state of Oregon. The expertise within its consultancies, utilities, manufacturers and innovators provide world-class engineering products and services, not just to Oregon customers, but to clients worldwide. This formidable economic cluster depends on a vast institutional knowledge built up over generations by a well-educated engineering workforce. Our objective in formulating this plan for the Oregon Power Engineering Project is to provide a reliable workforce pipeline of well-prepared engineering graduates. The next generation of power engineers will not only maintain this institutional knowledge and ensure the success of the Portland Power Pool, they will also further expand the industry's significance to Oregon's economy.

The framework proposed in this document is a collaborative unification of the three power engineering programs in the state of Oregon; offered at Oregon Institute of Technology, Portland State University and Oregon State University. The Oregon Power Engineering Education Project will leverage existing university resources, eliminate redundant educational investments, and evolve the educational paradigm for power engineering education in Oregon. The proposed educational platform should incorporate innovative teaching methods and experiential learning; develop close collaboration between universities and industry; and employ measurable outcomes to justify investment. These efforts will provide a power engineering workforce pipeline that will benefit the graduates of the state's engineering schools, the companies of the Portland Power Pool and the overall economy of Oregon. Addressing the engineering education needs of the power industry is vital for meeting Oregon's 10-year energy goals, its ambitious RPS target, and the mandates of the Oregon PUC.

Demand For Personalized Medicine

Abstract

Advancements and focus in the personalized therapeutics industry has the potential to radically change the face of patient experience and healthcare. The current healthcare system rewards providers for the volume of care provided rather than for favorable overall outcomes. Of course the health of the patient has been and will remain extremely important, but given incredible costs associated with healthcare in the US, the industry is demanding better and more potent solutions. Additionally, there is greater recognition that each patient has unique characteristics and there is often no single therapeutic solution to cover a wide range of individuals, an idea that has only recently taken hold as a focus point for the healthcare industry.

"Biomarker-based companion diagnostics (CDx) designed to identify responsive patient sub-populations or those likely to experience adverse drug effects, lie at the heart of this personalized, precision medicine movement."

This is not to say that patient medical history is not included in most patient visits, however, major advances in the amount of information (personal health history, environmental, genomic, etc.) that can be gathered on individuals has reached such volume that much of the information has been unanalyzed.

Applications for a personalized medicine approach to treatment clearly spans across many situations demanding even remotely customized treatments from intravenous uses to pharmacy prescriptions, however,

one of the biggest opportunities for personalized therapeutics is in cancer treatment.

> *"Never before had the need for personalized cancer medicine become so apparent. If each individual's cancer is unique, then new diagnostics and treatment approaches would have to take this into consideration."*

As many of us have seen, cancer can take an incredible toll on individuals resulting in additional health complications or at worst death. Personalized medicine offers the potential to explore options such as stimulating a patient's immune system into fighting the disease instead of subjecting the patient to generalized, debilitating rounds of chemotherapy. There has already been success by Merck & Co on the frontier of personalized cancer treatment.

> "MK3475, being developed by Merck & Co., is among a new category of drugs that release the brake, unleashing an army of immune cells to hunt down the cancer."

Results from these initial testing showed a 51% reduction in tumor size as a result of a targeted approach. Obviously, similarly targeted drugs are already in the regulatory pipeline.

Clearly there is need and opportunity for firms to develop better approaches to personalized medicine. Cancer treatment is one of many applications that advanced genetic knowledge will bring, resulting in more accurate treatment and certainly a growing focus at OHSU.

Impact

In addition to understanding the benefits of focusing on personalized medicine, the economics of this decision also need to be briefly examined. The US healthcare system, while heavy with annual expenditures, still ranks very low in virtually all metrics including patient care and cost. Investing in personalized medicine may trigger higher initial costs, due to more extensive diagnostic testing and certifications of treatment, however, the

long-term impact will most likely lower the overall cost to US healthcare.

"A recent OECD report estimates healthcare expenditure for some of the developed western and eastern nations to be anywhere from 1096 to 1896, and growing (with the US at the highest). Personalized medicine aims to use state-of-the-art genomic technologies, rich medical record data, tissue and blood banks and clinical knowledge that will allow clinicians and payers to tailor treatments to individuals, thereby greatly reducing the costs of ineffective therapies incurred through the current trial and error clinical paradigm."
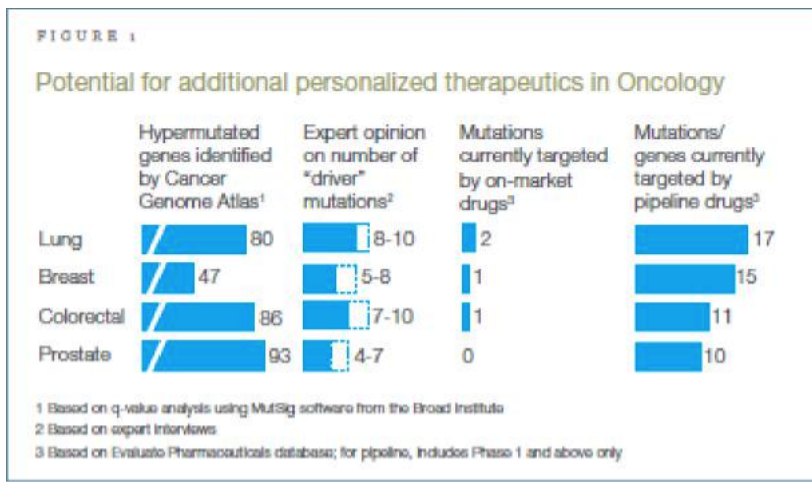
Existing treatment methodologies, which tend to generate repeat visits to hospitals due to ineffective treatment, only slows the healthcare industry and serves to increase overall cost. Given the recent changes, as a result of Obama Care, a new model of pay for performance is slowly taking the place of volume performance. This is forcing the healthcare industry to more heavily focus on the correct treatment the first time in an effort to generate the best outcome. In fact, due to the pay for performance model, those providers that do not adopt more personalized approaches run the risk of losing funding. It is then very reasonable to conclude that therapy research, which will gain federal funding, will be more focused on delivering the right solution the first time. Thus, we believe that a greater concentration on personalized medicine will not only improve healthcare practices, but will garnish significant funds for future research. Furthermore, these funds will not be restricted to federal dollars, and as the demand for personalized medicine increases, private and public firms will compete to sponsor future research.

As the industry transitions towards a more personalized treatment model, it is clear there will be both winners and losers determined by which companies can lower the overall net costs to achieve the same medical outcome. Even expensive diagnostics and treatments become attractive to the healthcare industry when compared to less expensive, but also less effective alternatives. Even advanced chemotherapy drugs are

only 45% effective. This means that for the majority of patients, this treatment path is a waste of scarce healthcare resources. With targeted therapies, innovative companies will be able to offer drugs that accrue healthy margins while generating overall healthcare savings.

> "Molecular diagnostics are a very attractive market segment to target due to the potential for significantly higher prices and gross margins."

In addition to higher margins and better healthcare, projections in the development of personalized therapeutics growth are quite high according to McKinsey's analysis.

FIGURE 1

Potential for additional personalized therapeutics in Oncology

	Hypermutated genes identified by Cancer Genome Atlas[1]	Expert opinion on number of "driver" mutations[2]	Mutations currently targeted by on-market drugs[3]	Mutations/ genes currently targeted by pipeline drugs[3]
Lung	80	8-10	2	17
Breast	47	5-8	1	15
Colorectal	86	7-10	1	11
Prostate	93	4-7	0	10

1 Based on q-value analysis using MutSig software from the Broad Institute
2 Based on expert interviews
3 Based on Evaluate Pharmaceuticals database; for pipeline, includes Phase 1 and above only

> "Majority of experts believe that use of advanced diagnostics for therapy selection will have exponential growth."

The table above shows that not only is the growth potential high for personalized medicine, it is in fact exponential, and as more diagnostic tools are developed, the demand will jump dramatically due to the positive results.

Advantages from personalized medicine to the economy are vast. Not only will patients experience better practices, but those firms that develop and bring personalized medicine to market will experience major profits in the long term. It is the conclusion of this analysis that investment and development of this sector will result in exceptional monetary returns.

Future Applications - Big Data

Given the tremendous advances in genetic biology and personalized therapeutics, a rising demand in digital applications, such as those that can quickly and accurately analyze, has spurred a relatively recent growth in the data storage and analysis market.

> "There is tremendous (and fully justified) excitement surrounding the growing use of next generation DNA sequencing technologies

in clinical practice, but the academic community is not prepared for the tsunami of data that will ensue." –Charles Sawyers, MD Sloan Kettering Cancer Center.

This employment demand will be focused on highly skilled individuals that possess big data knowledge/ experience as well as some scientific training. That said, an individual need not be an expert in the medical field, but rather possess the ability to critically think and decipher complex and revealing data. In essence, the trends of the past decade, which focused on greater education and need in the computer science industry, will and are already intersecting with the healthcare field.

 The reality of genomic analysis in personalized medicine is that there has already been investment to address the rising need for cheap and fast sequencing. Companies such as Life Technologies already developed a chip that can sequence an entire genome in less than a day for under $1,000. The issue arising from this advancement is the lack of analytics software and expertise to quickly, and cost effectively, pour through the raw data. In the graphic below a projection of the potential increase in sequencing data is represented, and shows that the demand for a solution will result in economic opportunity.

This information has been widely publicized and known for several years; however a dominant partner has yet to rise. Several healthcare providers are attempting to adapt more widely used EMR systems to incorporate broader data sources, but it is likely the analytics companies, who will in the near term, source this work and use it to provide even deeper insights regarding the patient's genome and optimizing health outcomes.

"Big-data initiatives have the potential to transform health care. Stakeholders that are committed to innovation, willing to build their capabilities, and open to a new view of value will likely be the first to reap the rewards of big data and help patients achieve better outcomes"

Data analytics and training are necessary for the future of personalized medicine. Faster processing and better analysis will result in greater gains both financial and academic.

In summary, Oregon and OHSU are is in a very good strategic position to grow this segment based on the momentum being gained at the Knight Cancer Institute and their historic success with Drugs like Gleevec. Though academic programs do not automatically translate into commercial success and economic growth, strong research and entrepreneurial ecosystem are usually an important factor. Those companies that can leverage this evolving healthcare treatment trend (and get involved before the curve plateaus) stand to be at the head of the industry, leading innovation and changing the face of healthcare.

Recommendations

Entreprenuerial Training

As ETIC evaluates OHSU's proposal for the graduate programs, it is important to consider the areas of the proposed program designed to prepare future graduates for successful industry careers. This belief is relevant based on the employment shift among post-doctoral candidates over the last decade away from teaching track careers. In the mid 1970's over 75% of graduating students pursuing doctoral degrees in bioscience related programs went on to pursue a tenure track position. In 2012 less than 20% are now pursuing teaching positions. The implication for how graduate programs are designed and structured is profound.

One of the participating review companies had participated in a comprehensive study of how the university could encourage their faculty to work more extensively with "industry." After interviewing many of the professors in the targeting academic programs, they discovery a common driving motivation—brokering employment for their students. Most of the professors active in soliciting cooperative industry projects were motivated by the fact that only a small percentage of their graduate were destined to pursue tenure track

teaching positions. As such, they felt it was their obligation to help prepare to transition student on to other careers.

With the majority of successful Ph.D.'s now entering the commercial workforce, it is particularly important that traditional doctoral education programs be augmented with industry education and internship/mentoring opportunities. OHSU is clearly in the forefront of their peer institutions in broadening their program to include these opportunities for their students. As proposed, the OHSU ETIC submission outlines specific non-traditional curriculum and industry immersion opportunities (from joint research projects to required internships) to broaden their graduate's base of experience.

The companies interviewed for this assessment universally agreed that Ph.D. candidates that can work in the commercial environment will be stronger regardless of the direction their eventual career takes. As Jennifer Fox stated at a meeting where OHSU graduate programs were discussed, "Promising graduates student usually discover pretty quickly if the culture of a commercial research entity is for them."

As part of this exposure process Oregon Bio is well positioned to integrate graduates students into our existing industry training programs that would expose student not only to valuable curriculum, but also other professionals already working in the bioscience industry. Given that this training is already carefully vetted by industry resources and scientific leaders, it may allow students to increase the likelihood of successfully launching a company or join an existing business or start-up team. We are encouraged by the extent OHSU has been interested in nontraditional education and training alternatives to provide a unique program to train the next generation of scientist.

Finally, our generalized market research and industry interviews validated the multi-disciplinary approach OHSU's program exemplifies. The scientific and treatment breakthroughs expected from personalized medicine require the expertise of multi-disciplinary scientific teams. The best programs will embrace this approach and produce the best educated graduates.

Industry Executive Interviews

The final stage of the analysis was to interview a cross-section of companies/executives directly involved with the cancer diagnostic or therapeutic industry. The interview subjects were given the OHSU ETIC submission and ask to review and comment on the merits of the proposal from an industry perspective. As the interviewing organization, we constructed a list of standardized questions (see below) to solicit the feedback in as structured a format as possible

structured manner. Most of the companies asked that their specific feedback remain anonymous so the specific comments are left unattributed.

Company Interview List

Galena Biopharma (Portland, OR)
MolecularMD (Portland, OR)
Oligos Etc. (Tigard, OR)
Ubivac (Portland, OR)
Amplion (Bend, OR)

Industry Interview Questions:

Question #1: Do you believe that the market for personalized medicine based products and services will grow in the Portland area in ways that will fully utilize these graduates?

Question #2: Would the skills described in this program satisfy your target skill set for those employees?

Question #3: Does your company have plans to hire PhD level employees in the next ten years based on the current growth plans?

Question #4: What changes would you suggest to make these graduates more employablewithin this emerging life sciences sector?

Question #5: What is your favorite aspect of the proposed program?

Summary of Responses

The interviews were conducted with company representatives by phone and in person. The companies' responses have been included with the appropriate question. Given the evolving nature of this

emerging market some of the comments and feedback was contingent on a particular market development scenario or predicated on specific product adoption trends that cannot be known at this time. Where appropriate these external conditions are highlighted with the response.

Question #1: Do you believe that the market for personalized medicine based products and services will grow in the Portland area in ways that will fully utilize these graduates?

In general, most of the companies involved with the survey are directly involved with the cancer therapeutics market. However, not all the participant companies are specifically involved with products or services that would be categorized within the personalized medicine sector. Despite these differences, they were consistent in their assessment of the market growth potential of this sector and the opinion regarding market timing. Though the growth trend is established it is still early enough to gain market share as compared to other market leaders and traditional dominant geographic areas (San Francisco, Boston, San Diego, etc.)

All expressed confidence that the science, research, and development efforts within the industry indicate that the personalized medicine sector will experience rapid growth. There was wide consensus that personalize medicine as applied is make has made the most progress in cancer and that the work at the Knight Cancer Institute (if you include immunological breakthroughs) has taken a sound approach. Their general opinion was that it is always tough to train scientists for an emerging market, but that OHSU has chosen the area to focus on the infrastructure (genomics, data analysis, etc.) that will be required in one form or another by a broad spectrum of companies in the future.

Key Comments included:

"The Knight has definitely zero'ed in on some of the key technologies that will be required to driven innovation forward"

"Their recruitment strategy is likely to drive more commercial exposure and a desire for some early stage innovators to relocate to the area to take advantage of the potential to collaborate"

"If you compare the personalized medicine market today to its early days (even seven years ago), it is amazing how quickly it has become a widely accepted market trend."

Question #2: Would the skills described in this program satisfy your target skill set for future employees?

The feedback to this section was the most varied due the specific nature their individual businesses or their various stages of development. Most responders felt that even though they might not specifically be hiring these Ph.D.-level graduates, this program will be training individuals that other local organizations will be in need of. As they looked further into the future, the more advanced companies were more likely to need these next-generation scientists as specialized members of their team.

Key Comments included:

"There is no doubt that these graduates will be in demand, however, Oregon will need to continue to grow this sector to keep them here in Oregon."

"It is harder to imagine that if the Knight Cancer (Challenge) Grant is successful a person with a systems biology and genomics background won't be very employable."

"If I were getting retrained as a scientist I would be very excited to enter a program that would prepare me to play such an essential role it the development of new products."

"I think the skill set described will be valuable, but only if it is combined with other broader business skills so that graduate can become a more versatile team member."

Question #3: Does your company have plans to hire Ph.D. level employees in the next ten years based on the current growth plans?

This was a difficult question for most companies to answer given the stage of both the personalized medicine market and their own product development timelines. In addition, as small companies, most won't be hiring employees with the advanced education and skills envisioned in the program until they experience their next growth phase. However, four out of the five companies interviewed anticipated hiring Ph.D. level employees if they successfully execute on their business plans over the next two years.

Key Comments included:

"There is no doubt that these graduate will be in demand, however, Oregon will need to continue to grow this sector to keep them here in Oregon."

"It is hard to imagine that, if the Knight Cancer (Challenge) Grant is successful, a person with a systems biology and genomics background won't be very employable in Oregon."

"I think the skill set described will be valuable, but only if it is combined with other broader business skills so that the graduates can become more versatile team members."

"We recently established an out-of-town subsidiary to support our growth plans because we couldn't hire the right candidates from the local work pool."

Question #4: What changes would you suggest to make these graduates more employable within this emerging life sciences sector?

The consensus response to this question was balance preparation. These graduates will be most valuable if they are exposed to the latest scientific and technical training. In addition to next-generation systems biology and genomic techniques, they need to have practical skills and industry skills. They specifically mentioned how important it is to receive some of their training outside the laboratory and the classroom. With the personalized medicine market at such an early stage of development, respondents were generally concerned that there won't be sufficient opportunities to expose each member of the first cohort of these students to internships within local, personalized medicine companies.

However, they also stressed that even experience in a commercial bioscience setting that is not focused on their specific area of study would help sensitize them to mindset of a product or service-oriented business. Several respondents mentioned the value of combining

various regulatory, project management and quality control training sessions with the industry internship component. These topics are generally better taught in conjunction with a practical work experience.

Key Comments included:

"It would be great if the graduates had already taken some of the most relevant BioPro classes (offered by Oregon Bio) so they don't have to learn about regulatory issues on the job."

"There will need to be greater coordination between industry and OHSU if we hope to place these Ph.D. candidates into high quality internships. They need to be exposed to industry before they would be useful as an intern."

"Schools in general need to be as flexible as possible in coordinating internships with the student's academic schedule. Opportunities sometimes emerge quickly—the best opportunities might not always match the academic calendar."

"We have used OSU students from their Professional Science Masters program in the past. These excelled because they were ready, from their first day as interns, to manage well defined projects or work as a team member. Of the three that interned with us, we hired two."

Question #5: What is your favorite aspect of the proposed program?

Though most respondents complimented the timing of the program with the Knight Cancer Challenge and the expected growth in the industry, the favorite aspect most referenced was the multi-disciplinary approach they are taking in designing the curriculum. Though none of the respondents claimed to have any significant experience with curriculum design, they agreed that the specific nature of the personalized medicine sector will require cross-discipline research and product teams. The goals outlined in the proposal clearly demonstrated that OHSU's team is considering this important factor and incorporating it into the design of the program. Given that this is not a common approach, it remains to be seen if it can be effectively deployed in such a way to retain students through the program.

There was less agreement in selecting a least favorite aspect to the program. In general, the least positive feedback related to the difficulty most universities have in integrating a consistent industry connection with such long-term programs. It seems to be less an indictment of the program than a hurdle that has been difficult to overcome in the past. There was general pessimism regarding any academic institution's effectiveness in providing industry exposure without substantial commercial partnerships and professional training.

Key Comments included:

"The Knight has definitely zero'ed in on some of the key technologies that will be required to drive personalized medicine innovation forward. This program would be an excellent way to cross-pollinate the cutting edge research with leading industry companies."

"The success of their program, and the current momentum behind personalized medicine, is likely to drive more commercial exposure and a desire for some early stage innovators to relocate to the area to take advantage of the potential to collaborate within an emerging personalized medicine cluster."

"The fact that they are taking a multi-disciplinary approach to the curriculum means they understand how complex the problem is. If this approach is embraced by their students they will be that much better prepared for careers in industry."

"The approach OHSU is taking to recruit younger, more innovative research with something to prove will accelerate the pace of innovation. The challenge will be to create both an institutional and industry ecosystem to allow Oregon to retain these scientists as they hope to commercialize their inventions."

Conclusion

The majority of the feedback provided through our industry interviews strongly favors funding this OHSU funding proposal. There is clear agreement that personalized medicine is still an early stage market where Oregon has already seen some success. This early validation and funding had allowed Oregon to gain an important foothold in this market. Because the market is not fully formed, critics may consider this approach to be somewhat speculative. However, the interview respondent generally felt that the market growth trends for personalized medicine are indisputable and Oregon should aggressively building academic and commercial infrastructure to seize its share of this economic growth. Though OHSU's Quantitative Bioscience & Biomedical Engineering program might appear to some as "forward leaning" initiative, the timeframes required to generate the expertise require a very pro-active approach.

Oregon Bio recommends fully funding the OHSU Quantitative Bioscience & Biomedical Engineering program. If funded, Oregon Bio will be an active partner in leveraging this new program to recruit companies to Oregon and work with our industry members to create both professional training and internship opportunities for students enrolled in the program. As an industry association we are confident this will become a valuable new component to Oregon's economic future.

Big Data and Data Scientists

Abstract

Big data is a growing field that is already or will be part of almost all Oregon industries. Developing students at Oregon Universities to meet the challenges of intelligently generating, curating, storing, managing (security) and analyzing big data are essential to maintaining and building industrial strengths with big data components in the state of Oregon. Additionally, there is increasing demand for data scientists solve complex data problems through employing deep expertise in some scientific discipline.

Impact

Big data impacts most industries in Oregon as well as nationally and globally. Generating, managing and analyzing big data as rapidly as possible provides companies with competitive advantages. This includes software and hardware industry, Internet and information technology industry, gaming (video and web) industry, healthcare industry, service industry (energy, food, transportation, etc). Access to well-trained employees who can generate, manage and analyze big data is vital to the success of Oregon businesses.

What is industry unable to do, or do well, at this time as a consequence of a critical, urgent, unfilled workforce need?

Oregon Industry is struggling to find skilled workers who can help them use their big data effectively to boost their productivity.

What is the scope of the industry sector(s) affected?

Most industry sectors are affected with software and hardware industry, Internet and information technology industry, gaming (video and web) industry and healthcare industry voicing their needs.

Does Oregon have a unique opportunity?

If Oregon can provide outstanding students with expertise in generating, managing and analyzing big data this could provide a basis for companies to relocate or startup in Oregon.

Participants?

The software and hardware industry, Internet and information technology industry, gaming (video and web) industry and healthcare industry will be strong initial stakeholders but other industries will likely be excited to have access to this skilled big data workforce.

Definitions

Big Data   Large amounts of structured and unstructured data (i.e. terrabytes) of structured or unstructured data that requires analysis to be useful for efficient decision making.

Data Science   Data science is the practice of deriving valuable insights from data. Data science is emerging to meet the challenges of processing very large data sets i.e. "Big Data" consisting of structured, unstructured or semi-structured data that large enterprises produce.

Background and Scope

Many companies (for example IBM and Intel) discuss how big data is changing the world and industry. See http://www.ibm.com/big-data/us/en/ and http://www.intel.com/content/www/us/en/big-data/big-data-101-animation.html and the current workforce needs and expected growth for employees with the skills to generate, manage and creatively analyze big data.

Why is the need emerging now?

The need has arisen due to the year to year exponential growth of data that is accessible to businesses in all

industries. Studies have shown that businesses who can readily access and analyze relevant data not only make better and faster business decisions but also cause their businesses to grow faster than their competition.

Does this need require new skills, or is it just a capacity gap?

New skills are required to meet this need. Businesses need employees who can quickly gather relevant data from multiple sources (both internal and external to the business), analyze the data, and eventually help predict how busines will perform in the future. For businesses to be competitive this is a must-have skill.

How broad is the need?

All industries in Oregon are affected by this. Without these skills, Oregon businesses will become uncompetitive thus adversely affecting the Oregon economy.

How predictable is the need?

The technologies are rapidly evolving so it will be important to train students who are adaptable problem solvers.

Who is serving this need now?

Broadly computer scientists, data scientists, statisticians, engineers and others with STEM training are serving the needs.

What are the consequences if the need goes unfilled?

Oregon will need to recruit out of state and compete with other states for this workforce.

Recommendations

Who is likely to use the system?

Students at all levels (undergraduate, masters and PhDs) who want big data training and jobs in the many industries looking for these scientists. Some Universities may be able to adapt their current programs to train these students while other Universities may need to create new programs to meet the training needs of these students.

How will we know if the need is being met?

Universities should drive capacity for internships at all levels (bachelors, masters and PhDs) and engage industry in developing the curriculum. If possible have industry provide appropriate big data projects and bring them into the classrooms for some targeted lectures to the students.

How do you recommend setting up the education delivery system to best respond to unexpected or emerging needs?

If possible it would be best for the education system to remain nimble and be able to adapt to the rapidly changing big data challenges and workforce needs. Here are several examples of possible student profiles and both the undergraduate and graduate level.

Undergraduate level examples:

Life Science students with computational skills – training of students to handle the large biological data sets being generated at an unprecedented rate. One approach is to take undergraduate students in the biological sciences and cross–train them in computer science. These students will take a sufficient number of computer science and statistics courses so they are able to effectively use the many available programs available for analyzing the large biological data sets that are being rapidly generated in academic and industry labs. Some students may develop the interest and skills to develop computational tools and become programmers that help develop the next generation of tools, but most of these students will use be users of the technology and more focused on answering biological questions.

Computer science students with a sophisticated understanding of biology – A second approach is to take computer science students with expertise in programming and cross-train these students in Biology.

The courses would be molecular biology and would focus on genomics and human disease. In addition to course work the students would be exposed to experimental approaches. For example, creating next-generation sequencing data from cell or animal models to test a specific biological hypothesis.

Students with from these two backgrounds could be brought together to build teams with different strengths and skills that would foster peer teaching and learning. The goal will be to recruit these students early in their undergraduate careers for this cross-training and encourage them to obtain internships with local industry to build their skills.

Masters level example:

Data Scientists – These students will be trained to analyze the massive heterogenous data sets being generated from the Internet and personal devices. Course work will be in computer programming, statistics and the use of programs such as R and technologies such as Hadoop and Spark. The students will take courses for 9 months and will have several projects based on data from Oregon industrial partners. The second half of the program will be a 6 month internship with Industrial partners with the goal of students transitioning into positions directly from their internships.

PhD example:

Quantitative Bioscience and Bioengineering PhD Scientists – PhD scientists will be trained for the growing challenge of delivering personalized medicine and for the development of new medical devices. These scientists will take course work in biomedical engineering, bioinformatics, genomics and computational biology as well as genetics, pharmacology and systems biology. The skills from their course work will be used to answer important biological questions with quantitative approaches. Partnering with industry through internships for these PhD scientists would provide additional cross-training and create potential new collaborative opportunities for both Industry and Academia.
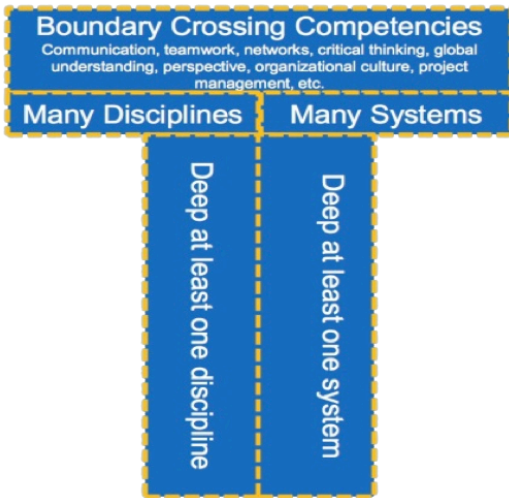
Developing T-Shaped Professionals

Abstract

Oregon's Engineering and Technology Industry Council (ETIC) is seeking proposals from post-secondary engineering schools that place an emphasis on the development of "T-shaped" professionals: that is, graduates with deep expertise in a subject area coupled with a breadth of capabilities that enable them to make contributions within the work of a diverse team to solve complex problems. This focus is based on the results of the 2013 ETIC's Employer Survey—which echoes national studies—in pointing to significant room for improvement in university engineering and computer science programs' production of such skilled professionals. ETIC will place priority on proposals that build on documented, existing best practices and/or promising practices identified in the research, and that demonstrate clear assessment rubrics and measurable outcomes for use by ETIC in evaluating program effectiveness.

The following report is a resource guide to help identify such best practices for use in future ETIC proposals. ETIC anticipates that program proposals may not be comprehensive, but could address the development of one or several identified "T-shaped skills"—such as written and oral communication—within one or multiple target segments of the student body.

Boundary Crossing Competencies
Communication, teamwork, networks, critical thinking, global understanding, perspective, organizational culture, project management, etc.

Many Disciplines | Many Systems

Deep at least one discipline | Deep at least one system

Producing T-Shaped Professionals

Today, industry needs employees with abilities that transcend the usual boundaries of academic disciplines as taught in most US engineering schools. Employers are placing increasing importance on skills and attributes that allow employees to solve complex problems within diverse organizations operating in a global society. Individuals with these abilities are often referred to as "T-shaped professionals."

In the T-shaped model, the horizontal bar or "dash" of the T represents broad cross-disciplinary skills and attributes such as communication, teamwork, networking, critical thinking, global understanding, and passion for lifelong learning. The strong vertical bar of the T represents depth of knowledge in a discipline, essential for an employee's effective contribution to an organization.

The American Society for Engineering Education, the Accrediting Board of Engineering and Technology , the National Academy of Engineering and other important professional organizations have recognized the need to transform US undergraduate engineering education to better prepare graduates for workplace environments of increasing complexity, in roles that now typically cross disciplinary boundaries. In late March 2014, a "T Summit", sponsored by IBM and Michigan State University, attracted academic and industrial leaders from around the world to contribute best thinking toward the development of T-shaped

professionals. Themes emerging from this international conversation included the dramatic rise of the level of skills required in entry-level college hires, difficulties in educating T-shaped professionals in single-discipline focused academic environments, and the need for more effective industry-university collaboration in the process of education transformation, including partnerships in faculty development.

ETIC Survey Highlights Importance of and Need for T-shaped Skills in Oregon

In Oregon, the Engineering and Technology Industry Council (ETIC) commissioned a 2013 study of Oregon technology employers to assess the importance of various technical and non-technical skills, and the level of satisfaction with these skills in recent graduates from Oregon's engineering programs. Designed and administered by the Oregon University System Office of Institutional Research, the survey was distributed to engineering hiring managers, CEOs and other senior executives, and human resources professionals from technology-related firms throughout Oregon. A total of 286 responses were received, representing a wide range of industry sectors around the state.

This survey's most striking finding was the wide gap between high level of importance and low level of satisfaction with Oregon engineering graduates in skills and attributes associated with T-shaped professionals, including:

- written communication
- getting things done in a complex environment
- verbal communication
- client interaction skills.

These Oregon results mirror the findings of national studies, including those developed by the National Association of Colleges and Employers, Manpower Inc., the Lumina Foundation, the American Society of Engineering Education (ASEE) and others. Employers highly value "soft skills " and the ability to collaborate and integrate work across disciplines and cultures in employees--but are less than satisfied with the preparation of new engineering college graduates in these areas. Among the Knowledge, Skills and Abilities (KSA's) identified in national studies as being of high importance to employers, written communication typically rises to the top as the skill in need of greatest improvement in recent engineering graduates.

T-shaped Skills and Engineering Program Accreditation

Since 2000, the Accrediting Board of Engineering and Technology (ABET) has recognized the importance of the development of T-shaped competencies in engineering students, in addition to the development of technical competencies. Assessment of student outcomes in T-shaped areas of written communication, verbal communication, functioning on multidisciplinary teams , ethics, understanding global, economic, environmental and societal context, and engagement in life-long learning is now required of all accredited US engineering programs.

However, challenges persist for engineering institutions to implement effective programs to develop such skills. Some often cited barriers include:

- Engineering curricula built around single-discipline academic departments
- Lack of effective engagement between industry and universities
- Lack of funding for academic innovation.

As national discussions between industry and universities about the development of T-shaped professionals gain momentum, action at the state level is needed today to better prepare Oregon's engineering and technology students for effective participation in Oregon's technology workforce of tomorrow.

ETIC Proposal Evaluation: Developing T-Shaped Professionals in Collaboration with Oregon Industry

ETIC encourages Oregon's post-secondary institutions to propose programs that will prepare Oregon students to become the T-shaped professionals increasingly demanded by industry. Postsecondary institutions or collaborations of institutions should submit proposals designed to produce specific outcomes in students, related to specific skills or attributes needed by industry.

Since no one program can effectively develop every aspect of becoming a T-shaped professional in every company, ETIC anticipates that institutions will propose programs which develop various skills or attributes needed by industry, producing varying outcomes, delivered in varying formats, and for varying student types. Programs may be designed for undergraduate students, graduate students, and/or students engaged in continuing professional education.

The common elements of all successful proposals will be:

- Programs will demonstrate meaningful partnership with Oregon Industry. Programs proposed should be developed with, implemented with and assessed by industry.
- Program design will be built upon best practice-either from successful initiatives at the institution which have produced documented results, or as identified in the literature.

Based on the best practices outlined in the following sections, proposals should address the following areas which ETIC will use in the evaluation process:

- Clear description of program, including skills developed, target students and methodology
- Extent to which program is embedded in the curriculum
- Assessment plans including rubrics, aligned with ABET assessment where appropriate. Anticipated outcomes and metrics for evaluation
- Budget and sustainability plan
- Plan for industry validation of learning (possibly including digital badges)

Best Practice Models

The National Academy of Engineering (NAE) report: Infusing Real World Experiences into Undergraduate Education, provides 29 exemplar models of US undergraduate engineering program initiatives that make a difference in developing skills in students, in ways that are authentic to industry. http://www.nae.edu/65099.aspx

Best practices highlights include "incorporating multidisciplinary team-based projects into curricula to help students develop skills in decision making, leadership, written and oral communication, organization/time management, cultural awareness, and problem solving. …. Case studies in the report compare anticipated versus actual program outcomes to demonstrate how each institution is improving the level of preparedness of its engineering students."

Program types profiled include: First Year Experiences, Curricular Experiences, Capstone Courses, Co-Op Experiences, Global Experiences, and Co-curricular and Extracurricular approaches.

Features of exemplar programs include: Multi-disciplinary approaches, team-based projects, active learning, and strong assessment.

The NAE report case study summaries provide clear program descriptions, anticipated and actual outcomes, assessment methods including mapping to ABET where appropriate, and sustainability plan information. References to the other university programs nominated for inclusion in the NAE's report may be helpful to universities seeking additional best practice models.

T-shaped Action Suggestions and Knowledge, Skills, and Abilities

With support from the National Science Foundation, the American Society for Engineering Education (ASEE) is developing a new strategy for undergraduate engineering education that meets the needs of industry in the 21st century.

The ASEE's May 2013 workshop report: Transforming Undergraduate Engineering Education: Phase I: Integrating and Synthesizing Industry Perspectives provides excellent framework for the development of T-shaped professionals, in partnership between universities and industry. The report also includes a

useful listing of Knowledge, Skills, and Abilities, including level of satisfaction with production of these KSA's in US engineering school programs. http://www.asee.org/TUEE_PhaseI_WorkshopReport.pdf

Highlights include:

- Successfully developing T-shaped skills in students is not a one-shot deal: at universities the concept should be embedded in university culture, in every class
- Production of T-shaped professionals is a shared responsibility between universities and industry
- Recommended concrete actions for university/industry collaboration including:

  1. Faculty internships in industry
  2. Company involvement in authentic learning throughout the curriculum
  3. Industry mentorships
  4. Shared laboratory experiences
  5. Internships and Co-ops