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Data Analytics of Job Market Requirements for Technology Related Doctoral Degrees

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Abstract

To remain competitive in the twenty first (21) century, industries are forced to rapidly embrace new innovations in both automation technology and information technology. This rapidly changing technological landscape has created a state of flux for industries and academia alike.

What is required of most workers in this millennia across the globe is technical skills and this requirement is heightened for workforce with graduate degree credentials. Today's work force are required to constantly keep up with new productivity improvement concepts, tools, and technologies. This necessity mandate continues education throughout one's working age.

In order to conquer this phenomenon, institutes of higher education and specifically doctoral granting institutions should meet the job market requirement through their curriculum. Curriculum must satisfy not only the today's job market demands but also foresee the future needs of society in general and industry in particular. Graduate curriculum must be rigorous and up to date with new and future technological innovation, managerial concepts, and problem-solving techniques in the global setting.

This research study analyzed data obtained through Digest of Education Statistics and custom-made Web Scraping (also known as Web Harvesting or Web Data Extraction) algorithm to decipher the expectation of today's job market from graduates with doctoral degree in technology and to identify graduate curriculum needs. The recommendations of this study are applicable to Doctoral programs in Technology and similar doctoral degrees granted at various universities.

Curriculum meeting the job needs help graduates to be competent in job market and acquire job easily, in addition, help schools to gain significant edge in quality of their graduates. In this paper, data analytics is used to identify current job requirement for Doctoral of Technology and similar degree programs. Highly required skill and knowledge set are obtained from job posting website via web scraping to assess the job market demands.

DATA ANALYTICS OF JOB MARKET REQUIREMENTS FOR TECHNOLOGY RELATED DOCTORAL DEGREES

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By

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Introduction

The curriculum plays an important role in education. It is considered as the "heart" of a learning institution which implies that schools or colleges cannot exist without a curriculum. Curriculum indicates what an institution values the most and what it expects from its graduates to achieve. Curriculum development process is needed as the technology improves and needs for the workforce changes. Job market requirements force curriculum developments. "Curriculum development is defined as a planned, purposeful, progressive, and systematic process to create positive improvements in the educational system" (Kranthi, 2017), Curriculum development is an integral part of education process to ensure that courses are best designed for obtaining the skills needed in the job market.

The basic purpose of curriculum development is to make sure that students get integrated, coherent learning experiences that contribute towards their personal, academic and professional learning and development (Staff at Flinders University, n.d.). With the help of well-designed courses, graduates have opportunity to penetrate in industry faster and be successful in their jobs. Curriculum development is not only important for schools but also important for the development of society in general. Mainly, for higher education, curriculum should be developed to ensure economic growth and stability of a country. Universities offer programs that are innovative and in demand in the local or global markets and can prepare students for the demand in industry. Thus, curriculum development has significant importance in setting the direction of change in an organization at the micro and macro levels.

Industries are rapidly growing and the world is changing daily due to technological advancement and competitive business practices. These advancements need to be included

into the education curricula. As the methods and tools employed in industry are changing promptly, professionals and educators are required to stay up to date and remain competitive in industrial and academic jobs. In order to meet industry and job market's demands, there is a need for universities to develop curriculum based on market's requirements. Curriculum development is more crucial for doctoral level education since it is an advanced level education where students study topics in a more in-depth method. Doctoral curriculum are expected to have the doctoral students master the topic and deliver the knowledge that she/he gains to others in her/his new job.

Curriculum development process is used to make progressive improvements in the courses offered at college/university. Curriculum development process involves evaluation of existing curriculum, modification of new and improved curriculum, implementing it and then evaluating the revised curriculum. Many schools follow a systematic and planned process for curriculum development which usually consists of four phases (Kranthi, 2017).

1. Research and Planning Phase: Information is gathered
2. Curriculum Development Phase: Curriculum map is created and the resource materials which will support the curriculum implementation are identified
3. Implementation Phase: New curriculum is placed into practice
4. Evaluation and Ongoing Review Phase: Curriculum is evaluated every now and then to determine the success of the program and it is revised if needed

This research paper focuses on first phase of curriculum development process which is the research and planning phase. The objectives of this phase are to understand the requirements, standards, and best practices in the industry and in academia, and to make a

plan for timely completion and implementation of the curriculum development. Planning phase consists of three main steps (Kranthi, 2017);

1. Formation/Selection of Curriculum Development Committee
2. Identifying the needs and trends in the contents of a program
3. Evaluating issues and needs

The second step for planning phase involves data collection. First, data is collected related to need in the program. Later, collected data is analyzed to identify the gaps in the existing curriculum and to determine the current and future requirements for the courses. Collection of data at planning phase is very important because it helps to understand and eliminate the discrepancies in the existing curriculum. In addition, it helps to improve the course structure based on present and future demand of the industry. In this paper, data analytics was used to collect and analyze data for identifying the desirable skills and knowledge set for Doctoral of Technology and similar degrees.

Data analytics is the science of examining raw data and draw conclusions about information it holds. Data analytics help organizations to understand available data, allows better planning opportunities for organization's future goals, and contributes to the decision making by providing educated opinions (Gandomi & Haider, 2015). During the process of data analysis, data is collected and analyzed to identify the pattern which are helpful to a particular organization's requirement. Similarly, this research paper uses data analytics method to evaluate market demand for the Doctoral of Technology and similar degree programs, to be used for curriculum development if needed.

Universities offer various doctoral degrees in Technology. Most of the degrees focus on specific area of study. Some of the programs are online for distant learning. Some universities have multiple Technology degrees. Table 1 lists some of the current programs in United States.

Table 1

List of universities with program names

University Name	**Doctoral Degree**
Bowling Green State University	Ph.D. in Technology Management with specializations in Construction Management Digital Communications Human Resource Development and Training Manufacturing Systems Quality Systems
New York University	Ph.D. in Technology Management
Purdue Polytechnic Institute University	Ph.D. in Technology with focus area in Aviation and Aerospace Management Computer and Information Technology Computer Graphics Technology Construction Management Engineering Technology Technology Leadership and Innovation
Portland State University	Ph.D. in Technology Management with four groups Management of Engineering and Technology. Innovation Management Project Management, Technology Marketing Strategic Management of Technology, Competitive Strategies in Technology Management Technology Assessment and Acquisition, Technology Transfer

University of Central Missouri	Ph.D. in Technology Management with specializations in Construction Management Digital Communications Human Resource Development and Training Manufacturing Systems Quality Systems
North Carolina A&T State University	Applied Science & Technology PhD Program Bioscience Applied Chemistry Applied Physics Data Science & Analytics Information Technology & Technology Management Atmospheric, Environmental & Energy Science
University of Northern Iowa	Doctor of Industrial Technology
Purdue Polytechnic Institute University	Doctor of Technology
Indiana State University	Ph.D. in Technology Management
North Central University	Ph.D. in Technology and Innovation Management
Colorado Technical University	Doctor of Management-Technology Management
North Carolina State University	Ph.D. in Textile Technology Management
New York University-Steinhardt	Ph.D. in Music Technology
Iowa State University	Ph.D. in Bio-renewable Resources and Technology Ph. D. in Industrial and Agricultural Technology Ph.D. in Food Science and Technology

Problem Statement

Current job market requirements need to be identified in order to be qualified for academic and industry positions. Skills and knowledge sets for Doctoral of Technology and similar degree programs need to be analyzed to make sure that curriculum is up to date.

Statement of Purpose

The purpose of this research paper is to analyze the market demand for required skill and knowledge set from the graduates of Doctoral of Technology and similar degrees. In addition, to identify employer requirement for industrial and educational job market, gathered data can also be used to provide feedback for the curriculum development.

Statement of Need

The demand and enrolments for doctoral degree are continuously increasing worldwide. Doctoral degree is one of the highest degree in academia and doctorates conferred in science, engineering, and technology fields are higher in value than non-science degrees. Doctoral degree is a big contributor to the development of science, engineering, and technology in industry and academia.

Curriculums of Doctoral Programs

The Doctoral of Technology programs varies in name such as PhD in Technology, PhD in Technology Management, Doctoral of Industrial Technology. Each program has unique curriculum which are focused on specific area. Several curriculums are presented in Appendix A (Portland State University, 2019), (North Carolina Stete University, 2019), (New York University, 2019), (Purdue University, 2019) (University of Northern Iowa,

n.d.), to compare with job market requirements and current search results. Further requirements for the programs involve publication. In some institutions, this requirement is supposed to be met before the approval of dissertation proposal or dissertation and doctoral candidate is supposed to indicate to the committee and advisor about the published, submitted, or accepted publications.

In some institutions, another requirement is internship which is considered as an opportunity for the candidate to utilize acquired knowledge and apply it to career related area. Doctoral candidate works as an intern either in cooperating agency or in industry under supervision of the advisor and this internship can also be related to the topic of research/dissertation. Furthermore, most of the programs have seminar courses.

Research Question

What is the current demand for Doctoral of Technology and similar degrees?

What is the current demands for the skills and knowledge set in job market from the graduates of Doctoral of Technology and similar degree programs?

What major skill and knowledge set should be included in curriculum of Doctoral of Technology and similar degrees to meet the job market requirements?

Literature Review

Graduate education has 800 years of history, it began back in twelfth century in Italy and Paris. It was adopted in other parts of Europe by mid-nineteenth century and in United States by late nineteenth century (Fecik, Varzavand, Pecen, & Teresa, 2003).

In recent decades, there has been a severe decline in the number of doctorate degrees awarded in technical education including career & technical education and technology education. Kenneth (1997) analyzed Industrial Teacher Education Directory in

1970 and then in 1990, there were 83 Doctorate in Education (EdD) and Doctorate of Philosophy (PhD) degrees awarded in Industrial Arts and Technology Education in 1970 and 50 degrees were awarded in 1990 which shows a significant decline. Based on the declining trend and further analyses, Kenneth (1997) predicted that by 2005 there will be downfall of industrial arts teacher education programs. He claimed that the main factor of predicted downfall is the absence of innovation and new ideas at the university level.

Later, Rogers (2002) analyzed the Industrial Teacher Education Directory 2000 edition, and found that there were only 19 graduates who received doctoral degrees in Technology education. Although Kenneth's prediction was about the downfall in 2005, this severe and steady decline in graduates since 1970 was alarming. Other findings (Reed, 2002) showed that there was significant decline in graduate level research as there were less number of dissertations and thesis in Technology education due to less people pursuing doctoral degree.

Furthermore, there was an unavailability of secondary school Technology teachers as well as there was increase in closure of programs (Bruening, et al., 2001; Rogers, 2002; Kenneth, 1997). Bruening et al (2001) conducted a survey of 359 Career and Technical Education (CTE) faculty and found that fifty years was the average age of CTE faculty, which indicated that if the existing faculty retires there will be a need for qualified educators at bachelor's level programs to fulfill the faculty requirement. Additionally, due to decrease in the number of graduate level research there was decrease in innovation in this field as well.

All these findings suggested a disturbing picture of the probable future for education and research within the field of Technology education. The lack of doctoral level

graduates at Technology education will lead to shortage of qualified professors/educators at bachelor's-granting institutes which will eventually lead to shortage of Technology teachers at secondary school.

In order to find out reasons for decline in the number of doctoral graduates, there was a need to look at the curriculum of Doctoral level education. In order to identify how doctoral programs should be redirected to meet existing need of the graduates and the profession. Paige, Dugger, & Wolansky (1996) indicated important factors for PhD in Industrial Technology education. Their results suggested that there were discrepancies in desired outcomes and mission statement of the program. Moreover in 2003, Fecik, Varzavand, Pecen, & Teresa,(2003) also investigated the challenges of graduate programs, they presented analysis of trends in graduate degree programs and the requirments of technical and industrial technology area.

Later in 2007, Baltzer, Lazaros, & Flowers conducted another research where they interviewed coordinators and program chairs of the nineteen different universities who were offering doctoral program in technical education such as 'PhD and EdD in Workforce Education and Development', 'PhD in Technology Management', 'PhD in Education with an area in Technology or Technology Education' etc. The results of the study suggest that field of doctoral education varies depending on the expectations of industry. Literature suggests that doctoral programs can be established based on different program requirements depending on market demand.

Additionally, according to the digests of education statistics (National Center for Educational Statistics, n.d.), until 2003, 'Industrial art education' and 'Industrial Technology' terms were used for one degree. Starting from 2004, these doctoral degrees

are listed separately. The data presented in the digests of education statistics show fluctuation in doctoral awards for Technology but the number has increased. Unlike the predictions of Kenneth (1997), there is increase in number of doctoral degrees conferred in last decade as compared to that of 2003. Figure 1 shows the increasing trend in Doctoral of Technology which refers to both PhD and EdD degrees (National Center for Educational Statistics, n.d.).

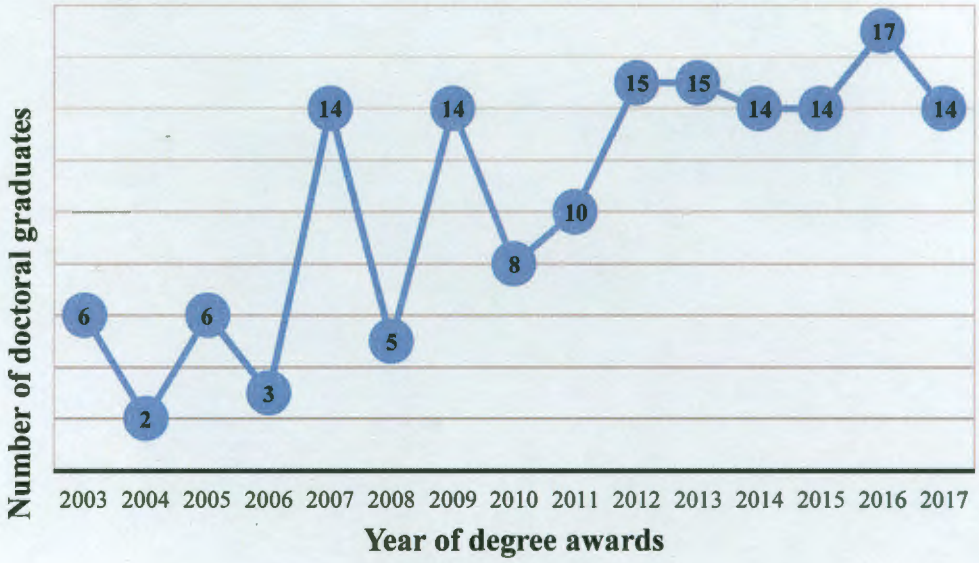

Figure 1. Doctorate degrees awarded for Technology

In addition, the records at digest of education statistics (Institute of Education Sciences, 2017) show that the total number of doctoral degrees granted in all discipline from 1970 to 2016 has almost tripled. Appendix B (Institute of Education Sciences, 2017) shows the records for the number of doctoral degrees conferred in various disciplines.

Similarly, survey of earned Doctorates (National Science Foundation, 2018a) conducted by National Science Foundation shows increasing trend in the number of doctoral degrees awarded by U.S. institutions from 1957 to 2016. Doctoral degree is the

highest degree in academia, and the trend in Figure 2 shows that large number of people are pursuing doctoral degree since 2000. Furthermore, the graph shows that the number of doctorates conferred in Science, Engineering and Technology fields have surpassed the number of non-science and engineering doctorates. From 1976 to 2016, there is an average annual growth rate of 2.0% for the number of S&E doctorate recipients.

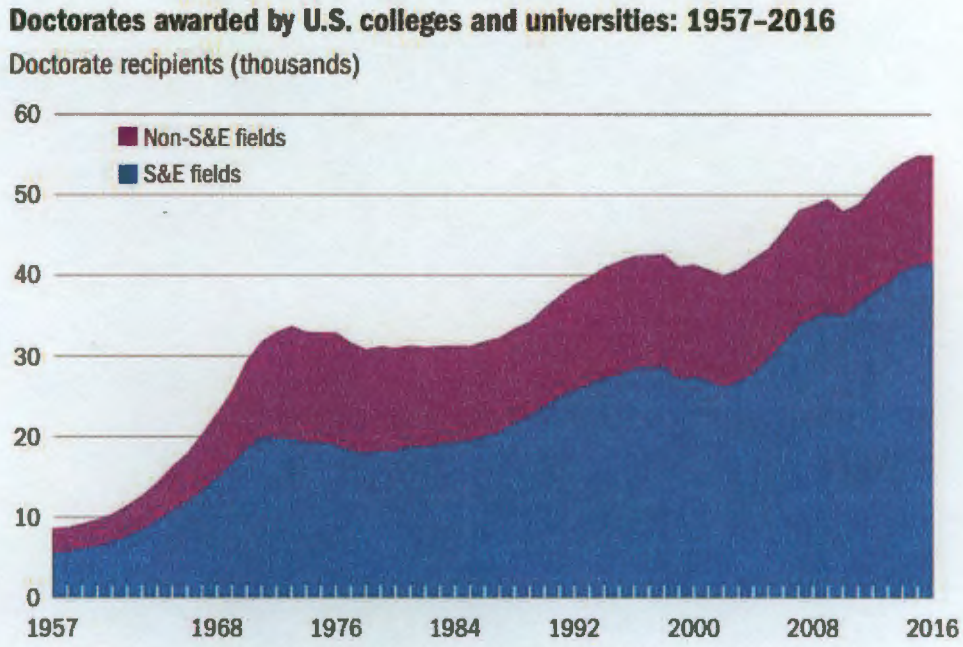

Figure 2. Doctorates awarded by U.S. colleges and universities from 1957 to 2016 (National Science Foundation, 2018b)

From this trend, it can be inferred that as the number of people who pursue doctoral degree is increasing, the number of institutes who offer doctoral degree is also increasing. In 1973, there were 286 doctorate granting institutions whereas 428 in the year 2017 (National Science Foundation, 2018b). The trend shows that the demand for doctorate degree is increasing which as a result contributes to the development in science, engineering, and technology.

Methodology and Description

In this research paper, a novel and simple method was developed to find required skill sets for Doctoral of Technology and similar degrees. Job postings are considered as convenient indicator of required skills in the job market. The purpose of this paper is to use data driven methodology to examine unstructured job posting data to first examine the need for Doctoral of Technology, and second identify what skills and attributes are required by employers from the graduates of this program. The importance and relatedness of skills mentioned in postings is directly related to occurrence of that skill, i.e. if one skill appears repeatedly in multiple jobs posts, it is highly required skill in market and it should be considered as a major requirement.

For this research, data was gathered from a well-known search engine "Indeed.com". It is a U.S. based search engine which is used worldwide to search for employment by job seekers. The collected data of job postings is limited to the current posting and no historical data is used in this study. Process of data extraction from website is referred as web scraping/web harvesting. There are multiple ways to scrap data from websites:

1. Online scrapping: There are several websites that can scrap data from target websites for the user/requestor. Some examples of such sites are parsehub.com, dataminer.com etc.
2. Scrapping software: There are several parsing software that can be used to scrap data from desired websites. Some examples are import.io, ParseHub, Octoparse, Content Grabber, Data Scraping Studio etc.
3. Programming code: Python, R studio and other programming languages can also be used with custom coding for scraping data from desired websites.

Online scrapping and software scrapers are suitable for small amount of data but the process is slow and may take days to extract data for large data extraction. Usually these websites and software companies have service fee to scrap large amount of data for the user for faster scraping using fast processing machines at their server.

In order to extract data for this research, initially open source software 'Octoparse' was tested. However, it was discovered that the approach was too slow and it was going to take several days to extract required data. Later, it was decided to use computer programming technique for this purpose. The main reason for choosing programming language as scrapping method was that it was much faster than other methods and provided the flexibility to write code for advance search. At indeed.com, advance search allows the use of special keywords for job search. For example, to find a job posting for candidates with an engineering technology and doctorate degree, the keywords must be entered as *engineering technology "doctorate"* and results will only provide job postings for doctorate level qualification. Python language program was used to scrap data from www.indeed.com and www.glassdoor.com. The program consisted of 85 lines of code which is presented in Appendix C. The program was developed from an already publicly available code (PHMark, 2018), however, it was significantly modified to meet the need of this research study.

Doctoral of Technology and related programs cover multiple curriculum domains and the search words which were used to collect data are given in Table 2. In addition, with each search word 'PhD' and 'Doctoral' terms were added to limit the search to the minimum required qualification level of Doctoral degree.

Table 2

List of search words for job postings

Serial. No	Search words
1	Career and technical education PhD or doctorate
2	Engineering technology PhD or doctorate
3	Industrial technology PhD or doctorate
4	Manufacturing technology PhD or doctorate
5	Technology education PhD or doctorate
6	Technology management PhD or doctorate
7	Workforce development PhD or doctorate

Glassdoor.com website does not allow scrapping desired results due to the backend algorithm which runs at their server to filter search results based on search words. The glassdoor.com website provides search results for each word separately. For example, to find a job posting for candidates with an engineering technology and doctorate degree, glassdoor.com will provide all jobs related to doctorate in all disciplines and search result for engineering technology wherever it occurs in job posting. Unlike indeed.com, glassdoor.com does not have advance search option. Therefore, search was made limited to only indeed.com. The number of jobs collected for each search word was not the same and some search words had more job posting as compared to the others. Later, all data was combined altogether and it consisted of 416 job postings. Based on search words, there was a possibility that few job posts were duplicated, hence, all duplicate entries were removed using Microsoft Excel. Due to diversity of search words, some irrelevant data was also picked up in search results such as 'Mathematics instructor' etc. In order to resolve this issue, all extracted job postings were thoroughly examined and irrelevant postings were

manually removed from the data. A total of 292 relevant job posts were finalized for the analyses.

Table 3

Description of dataset

Field	Technique	Description
Job Title	Scraped	Job Title as listed at website
Location	Scraped	City and state for the job post
URL	Scraped	Contains actual link for job post
Job Description	Scraped	Job details about experience, skills and education
Origin	Scraped	Company/University name
Job Category	Mined	Inferred category based on job title
Keywords/Skills	Mined	Extracted by SQL query from Job description

The data set consisted of seven different fields as shown in Table 3, five of which were scarped from website using developed python scraping program and remaining two fields were mined/extracted from the job description and job title field. Job category field was defined manually based on job title and details of 292 job postings. Jobs were categorized as a) faculty, b) industry c) administrative position in industry, and d) administrative position as faculty. Along with this, Keywords/Skills field was mined from job description field by running SQL (Sequential query language) query on description field for each keyword. Once the mined fields were formulated, job description field was omitted in further processing.

The keywords used for analyses of skills requirement for Doctoral of Technology and similar programs are; Academic Leadership, Administrative, Administration, Casting, Communication Skills, Construction Process, Curricular, Curriculum Development,

Engineering Design, Design Engineer, Engineering Process, Engineering Technology, Leadership, Manufacturing, Material Science, Optimization Techniques, Optimize Resources, Organizational Skills, Process Capability, Process Design, Product Development, Product Reliability, Productivity, Project Management, Quality, Quality Management, Risk Analysis, Risk Management, Technical Education, Technical Leadership and Technical Support.

Generally, in different job posts, multiple words are used to describe a single desired skill such as 'Administrative' and 'Administration' that are the two words to define one skill. For this reason, SQL query was run on description field using multiple keywords and later those keywords which were specifying same skill were combined together and duplicated job entries were discarded. Results section lists all those skills and number of times skills appear in extracted job posting data.

Results

There were 292 distinct job positions listed at indeed.com website relevant to Doctoral of Technology and similar programs. These jobs fall in to four different categories i.e. faculty, industry, administrative position in industry and administrative position as faculty. Figure 3 shows that for Doctoral of Technology and related programs, the highest job positions are in industry sector and then in academia. More than 40% of jobs are in industry and 31% are faculty positions at different colleges, remaining 29% constitutes for administrative positions in industry and academia both.

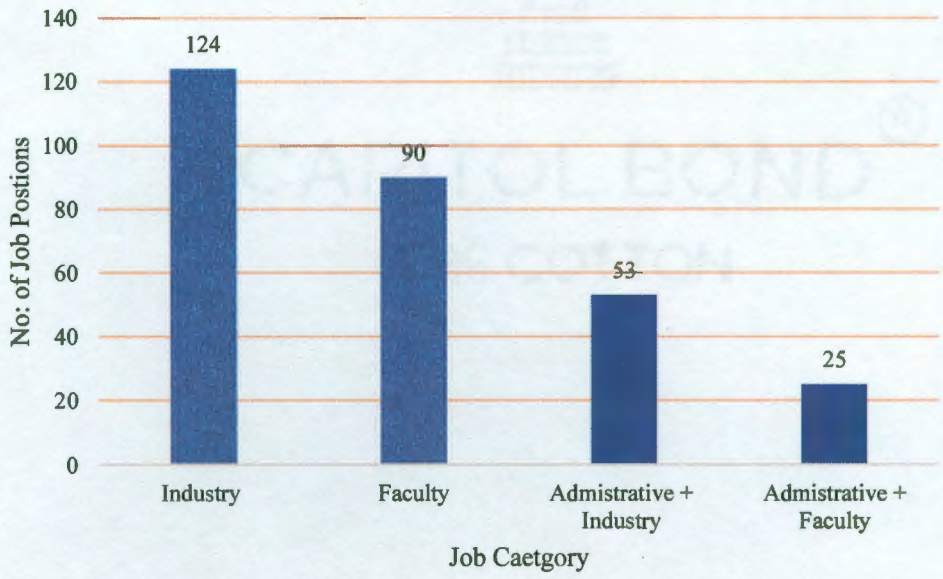

Figure 3. Number of job positions for each category

Different businesses and institutions require different knowledge and skill sets from their employees. Therefore, it is necessary to find out which skills can be useful for business professionals, educators, and for employers. In this research paper, skills and knowledge set are referred as 'keywords', which were extracted from job description field of scrapped data. List of those keywords/skills is presented in Table 4, which also categorize them based on each job sector.

This list of required skill set is a good representation of market demands. Skills collected from recent job posts give a clear indication of what skills are being expected from employees (graduates of Doctoral of Technology and similar degree programs) in academic and industrial job sectors. Table 4 shows the list of essential skills, and the number of jobs which ask for such skills. It also categories them based on job sector.

Table 4

List of keywords

Skill set/Keywords	Occurrence in Job	Category
Construction process	2	Industry
Optimization techniques	3	Industry
Organizational skills	4	Administrative +Industry
Process design	4	Industry
Casting	5	Industry
Technical leadership	5	Administrative +Industry
Process capability	6	Industry
Academic leadership	8	Faculty + Administrative
Material Science	11	Industry
Engineering process	16	Industry
Productivity	16	Industry
Technical support	16	Industry
Engineering Design+ Design Engineer	27	Industry
Technical education	32	Faculty + Industry
Product development	35	Industry
Risk Analysis +Risk Management	42	Administrative + Industry
Curricular+ Curriculum Development	55	Faculty + Administrative
Project Management	63	Administrative +Industry
Administrative + Administration	91	Faculty
Engineering technology	94	Faculty + Administrative + Industry
Manufacturing	110	Industry
Communication skills	111	Faculty + Administrative +Industry
Leadership	141	Faculty + Administrative +Industry
Quality +Quality Management	141	Administrative +Industry

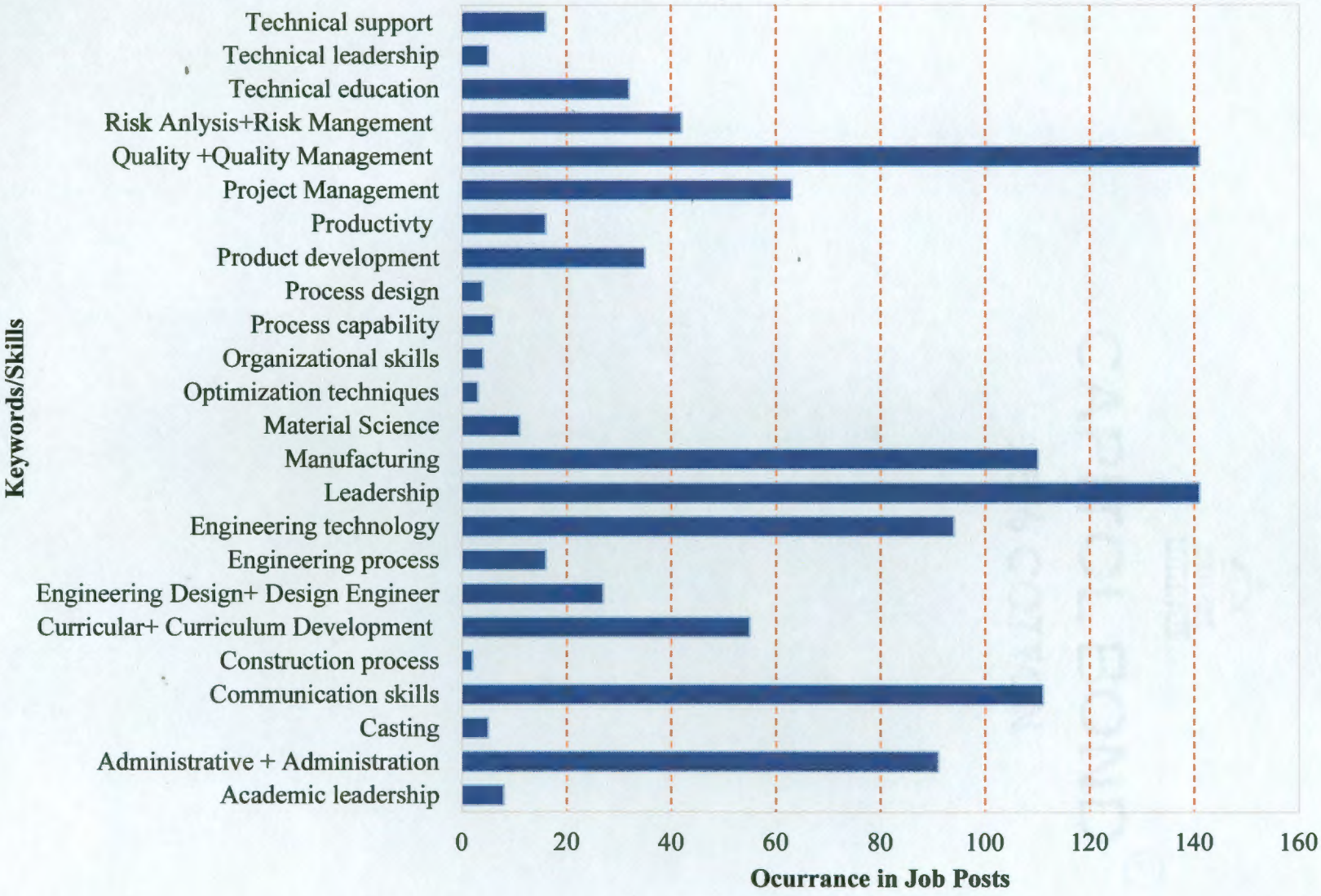

Figure 4. Occurrence of keywords in job posts

Figure 4 shows the pictorial view of this knowledge & skill set in terms of their occurrence/demand in market. Combining the information from Table 4 and Figure 4, some observations can be made about needed skills. These observations provide suggestion for institutes of higher learning and educators to shape their curriculum based on market demand. Due to rapid advancement in technology, skilled engineers are required for complex processes in industry and education. For example, a 3-D printer requires less time and material to produce complex designs but a 3-D printer is also an invention of skilled engineers for many such reasons technical skills are of utmost importance in industry. Technical skills such as process design, engineering process, construction process, and casting are required in industry. Along with the above skills, technical knowledge of product development, manufacturing, and engineering technology are in high demands.

Skills such as risk management, quality management, communication skills, and technical education fall into more than one job category and required more frequently. On the other hand, some skills are required for only two to three job postings but they are still needed. It should also be noted that, it is not only the technical skills which are required by employers but also managerial and administrative knowledge is valuable. This indicates that the job market values graduates/professionals with good business and technical skills much more than graduates/professionals having only technical knowledge.

It can be clearly seen that skills such as quality management, leadership, communication skills, and administration and project management are in high demand in market. These skills are required in industry, academia, and for administrative positions. These skills should be given high importance in the curriculum for Doctoral of Technology and similar degrees. Moreover, knowledge of engineering technology and manufacturing

process/planning etc. are also highly required. Almost all the skills and knowledge set mentioned in Table 4 can be very useful for development of curriculum for Doctoral of Technology and similar programs.

Additionally, results show that highest job position are in industry sector, which suggests that internship may also be helpful for the students since it provides real life experience and exposure for the candidates.

While analyzing market demand, it is also important to learn about the location where particular skills and knowledge is needed. Figure 5 at the end of results section shows 43 states that have job postings. Among the states, California has the highest vacancies whereas other states such as Illinois, Texas, New York, North Carolina, Pennsylvania and Virginia etc. have good number of jobs opportunities as well. The need for Doctoral of Technology and similar degree graduates in 43 states shows that graduates of these programs are required almost all over the United States.

Based on above discussion and observations from the scrapped job data, following suggestions can be made about the Doctoral of Technology and similar programs' curriculum content to meet today's job market demand:

1. Curriculum should be designed based on market demand of required skills and knowledge set.
2. Program should prepare graduating students to perform their job-related tasks independently as well as in teams in professional practice.
3. Curriculum content should include following courses:
    - Quality Management and Improvement/Tools for Quality Management
    - Project Management

- Effective Risk Analysis and Management
- Organizational Leadership Development
- Communication Skill for Professionals
- Administrative Procedures
- Product Development for Inventors

This list only suggests a few courses and more courses may be included from the list of required skills and knowledge set from Table 4. As mentioned earlier, more and more people are pursuing doctoral degree in the last decades, this paper suggests that the job market requirements need to be analyzed carefully to prepare the Doctoral of Technology and similar degree program graduates for their future positions.

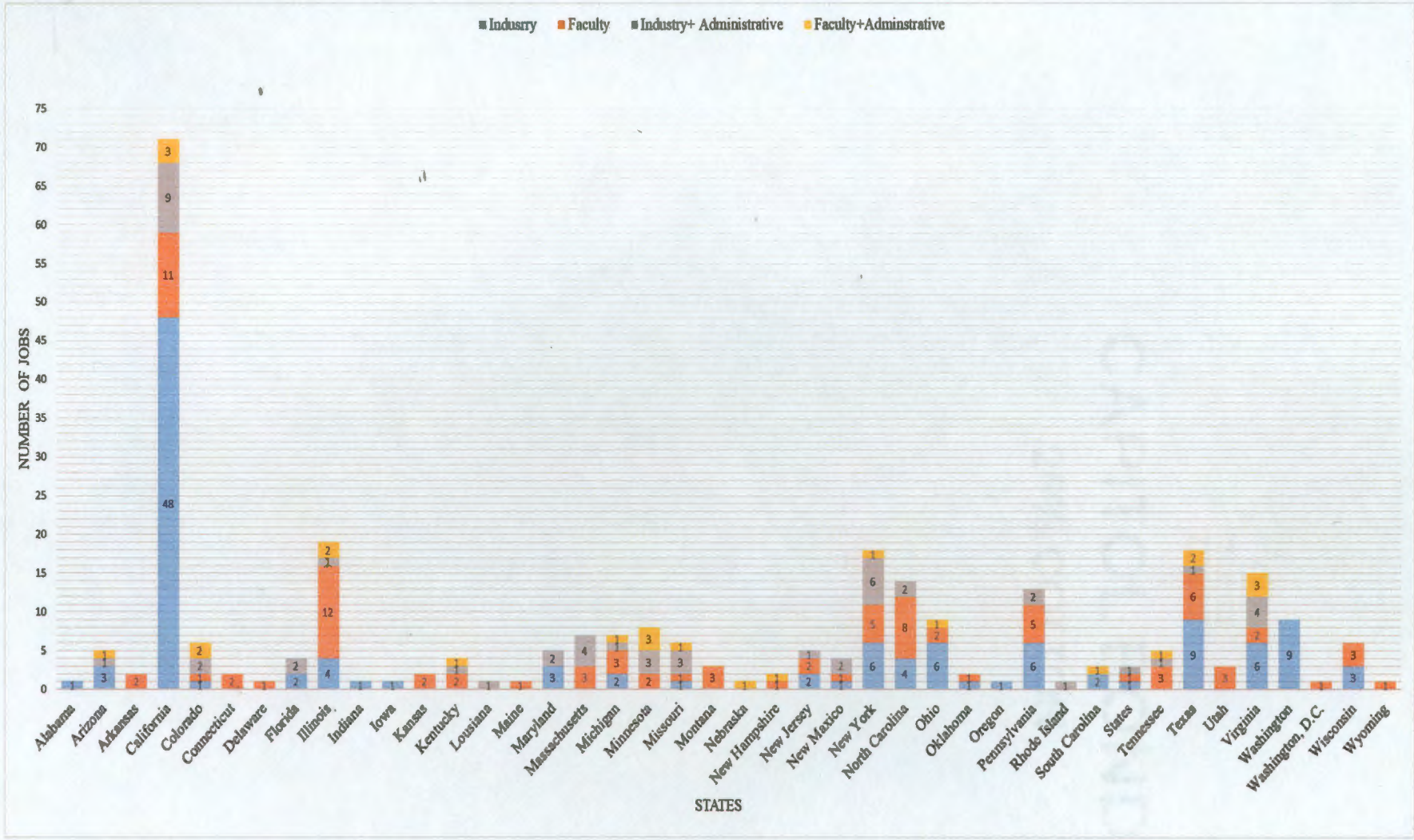

Figure 5. Job posting based on location

Conclusion

In this rapidly growing and fast changing technological world, blue and white color workers are required to have the ability to quickly adopt to the new demanding job market by learning new technological innovations and techniques. Advanced analytical, technical, and managerial skills are expected from all individuals with graduate degree.

Today's job market expectation demands productivity and efficiency from workforce from day one of employment to the last day before retirement. No longer are work force with graduate degrees tolerated to have slightest skills gap in their education.

Generally, it has been observed that industries are one step ahead of educational institutions in terms of what is required from the graduates with advance degree. Perhaps stronger partnership between industry and education may resolve this shortfall.

In this research paper, data analytics method was used to ascertain current skills that are required from Doctoral of Technology and similar degree program graduates. Extracted data provides a list of skills and knowledge set which is highly desirable in today's global job market. Results show that some institutions already offer the required courses in their curriculum. It is postulated that, recommendations of this research study on curriculum may indeed help schools of higher education to gain reasonable edge in modernization of their graduate curriculum as well as quality of their graduates. It should be noted that curriculum revisions require agility and foresight.

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Appendix A

University Name	Doctoral Degree	
New York University	*Ph.D. in Technology Management*	
	Management Core Courses	**Technology Management Courses (9 Credits)**
	Organizational Behavior	Organizational Theory & Design
	Marketing	Economics for Information Sectors
	Economics	Management of New & Emerging Technology
	Accounting & Finance	Managing Technological Change & Innovation
	Operations Management	Special Topics
		Associated Doctoral Seminars (12 Credits)
Portland State University	*Ph.D. in Technology Management*	
	Engineering and Tech. Management courses	**Courses from other PSU departments**
	Communications and Teambuilding	New Products Management
	Strategic Planning in Engineering Management	Global Sourcing and Supply
	Manufacturing Systems Engineering	Leadership and Group Effectiveness
	Manufacturing Systems Management	Advanced Industrial/Organizational Psychology
	Quality Management	Organization Development

	Technology Forecasting	Program Evaluation and Management
	Managing Intellectual Capital	Impact Assessment
	Ethical Issues in Technology Management	Value-based Management
	Technological Entrepreneurship	Complex Organizations
	Project Management Framework	Introduction to Database Management
	Project Management Tools	Cultural Economics
	R&D Management	Urban Economics
	New Product Management	Environmental Economics
	Managing New Technology Introduction	North Carolina University
	Human Side of Technology Management	
North Carolina A&T State University		
	Applied Science & Technology PhD Program	
	Information Technology & Technology Management	
	Reliability Testing and Analysis	Data Warehousing
	Enterprise Resource Plan Systems	Computer System Security
	Risk Management in Construction	Impacts of Technology
	Knowledge Discovery Systems	Managing New Product Development
	Network Service for the Enterprise	Sustainable Energy Systems
	Enterprise Management Systems	Environmental Energy Economics I
	Enterprise Management Systems	Special Topics
	Construction Cost Estimation and Project Construction	Specifications and Design
	Big Data Analytics	Secure Software Engineering
	Project Management for IT Professionals	Secure Social Computing

	Advanced Computer Integrated Production	Data Structures and Software Principles & Programming
	Integrated Product & Process Design	Computational System Theory
	Enterprise Integration	Digital Communications
	Nano Micro and Bio Manufacturing	Information Theory
	Service Sector Engineering	Advanced Robotic Systems
	Supply Chain System Engineering	Wide Area Networks
University of Northern Iowa	*Doctor of Industrial Technology*	
	Research Design in Industrial Technology	
	Historical and Contemporary Issues in Technology	
	Tech and Societal Trends: Case Studies	
	Technology, Ethics, and Leadership	
	Statistics	
	Technology Seminar	
	Electives	
	Supporting Course Work	
Purdue Polytechnic Institute University	*Doctor of Technology* (Hybrid or Online)	
	Technology Leadership in the Era of Social Media	
	Technology Research & Use of Data Analytics	
	Global Supply Chain Management	
	Leadership of CyberSecurity & CyberForensics	
	Global Perspectives on Emerging Technologies	
	Demographic Leadership	
	Analysis of Research	

Appendix B

Doctor's degrees conferred by postsecondary institutions, by field of study: Selected years, 1970-71 through 2015-16

Field of study	1970-71	1975-76	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total	**64,998**	**91,007**	**98,016**	**100,280**	**105,547**	**115,507**	**119,585**	**138,056**	**144,690**	**149,378**	**154,564**	**158,590**	**163,827**	**170,217**	**175,026**	**177,587**	**178,548**	**177,867**
Agriculture and natural resources	1,086	928	1,067	1,158	1,185	1,259	1,127	1,194	1,272	1,257	1,328	1,149	1,246	1,333	1,411	1,407	1,561	1,508
Architecture and related services	36	82	93	73	135	141	153	201	178	199	212	210	205	255	247	247	272	236
Area, ethnic, cultural, gender, and group studies	143	186	161	156	159	183	216	226	233	270	239	253	278	302	291	336	312	316
Biological and biomedical sciences	3,603	3,347	3,640	3,405	4,152	5,250	5,225	6,162	6,764	7,400	7,499	7,672	7,693	7,935	7,939	8,302	8,053	7,914
Business	774	906	808	923	1,185	1,366	1,180	1,711	2,029	2,084	2,123	2,249	2,286	2,538	2,828	3,039	3,116	3,323
Communication, journalism, and related programs	145	196	171	212	259	338	368	461	479	489	533	570	577	563	612	611	644	629
Communications technologies	0	8	11	6	13	7	2	3	1	7	2	3	1	4	0	3	0	4
Computer and information sciences	128	244	252	344	676	869	768	1,416	1,595	1,698	1,580	1,599	1,588	1,698	1,834	1,982	1,998	1,979
Education	6,041	7,202	7,279	6,610	6,189	6,246	6,284	7,584	8,261	8,491	9,028	9,237	9,642	10,118	10,572	10,929	11,772	11,829
Engineering	3,687	2,872	2,598	3,444	5,316	6,304	5,485	7,243	7,867	7,922	7,744	7,706	8,369	8,722	9,356	10,010	10,239	10,209
Engineering technologies	1	2	10	12	14	50	62	75	61	55	59	67	56	134	111	107	123	133
English language and literature/letters	1,554	1,514	1,040	895	1,056	1,395	1,330	1,254	1,178	1,262	1,271	1,334	1,344	1,427	1,377	1,393	1,418	1,392
Family and consumer sciences/human sciences	123	178	247	307	229	375	354	340	337	323	333	296	320	325	351	335	335	374
Foreign languages, literatures, and linguistics	1,084	1,245	931	768	889	1,020	1,078	1,074	1,059	1,078	1,111	1,091	1,158	1,231	1,304	1,230	1,243	1,265
Health professions and related programs	15,988	25,267	29,595	31,922	29,842	32,678	39,019	45,677	48,943	51,675	54,846	57,750	60,221	62,097	64,192	67,447	71,004	73,682
Homeland security, law enforcement, and firefighting	1	9	21	21	28	38	44	80	85	88	97	106	131	117	147	152	193	205
Legal professions and studies	17,441	32,369	36,391	35,898	38,035	39,919	38,190	43,569	43,629	43,880	44,304	44,627	44,853	46,836	47,246	44,169	40,329	37,030
Liberal arts and sciences, general studies, and humanities	32	162	121	90	70	75	102	84	77	76	67	96	95	93	98	90	96	105
Library science	39	71	71	62	56	53	58	44	52	64	35	64	50	60	50	52	44	54
Mathematics and statistics	1,199	856	728	742	978	1,158	997	1,293	1,351	1,360	1,535	1,596	1,586	1,669	1,823	1,863	1,801	1,850
Multi/interdisciplinary studies	101	156	236	352	306	549	512	600	683	660	731	631	660	727	730	769	840	849
Parks, recreation, leisure, and fitness studies	2	15	42	39	28	104	177	194	218	228	285	266	257	288	295	317	311	331
Philosophy and religious studies	555	556	411	480	464	550	600	578	637	635	686	667	804	778	794	698	762	746
Physical sciences and science technologies	4,324	3,388	3,105	3,521	4,248	4,589	3,968	4,642	5,041	4,994	5,237	5,065	5,295	5,370	5,514	5,806	5,823	6,016
Psychology	2,144	3,157	3,576	3,593	3,932	4,141	5,091	4,921	5,153	5,296	5,477	5,540	5,851	5,936	6,326	6,634	6,583	6,532
Public administration and social services	174	292	362	382	430	499	574	704	726	760	812	838	851	890	979	1,047	1,123	1,065
Social sciences and history	3,660	4,157	3,122	2,955	3,012	3,760	3,930	3,914	3,844	4,059	4,234	4,238	4,390	4,597	4,610	4,724	4,828	4,667
Theology and religious vocations	312	1,022	1,273	1,185	1,076	1,517	1,461	1,429	1,573	1,615	1,587	2,071	2,374	2,446	2,174	2,103	1,927	1,808
Transportation and materials moving	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	7	5	8
Visual and performing arts	621	620	654	722	838	1,067	1,167	1,383	1,364	1,453	1,569	1,599	1,646	1,728	1,814	1,778	1,793	1,808
Not classified by field of study	0	0	0	0	747	7	63	0	0	0	0	0	0	0	0	0	0	0

Appendix C

Python program

```
from bs4 import BeautifulSoup as bs
from selenium import webdriver
import urllib.request, urllib.error, urllib.parse
import re
import ssl
import pandas as pd
import numpy as np
import time
import unicodecsv as csv
import requests as NewRequests
from lxml import html, etree
import re
allUrlsInfo = []
class SoupMaker():
    """ A class that scrapes indeed's Job ads """
    def __init__(self, _url, _driver):
        self.base_url = "https://www.indeed.com"
        self.home_url = self.base_url + _url
        self.job_links = []
        self.driver = _driver
        self.job_datas = []
        self.job_table = []
        def read_page(self):
        self.ctx = ssl.create_default_context()
        self.ctx.check_hostname = False
        self.ctx.verify_mode = ssl.CERT_NONE
```

```
        print("Parsing: ", self.home_url)
        self.url = urllib.request.urlopen(self.home_url,
                        context = self.ctx).read()
        _soup1 = bs(self.url, "html.parser")
        self.a_tags = _soup1('a')
        def get_job_url(self):
        for link in self.a_tags:
            link = link.get("href", None)
            if link != None:
                cmp_url = re.search("^/.+/.+/jobs/.+", link)
                rc_url = re.search("^/rc.+", link)
                if cmp_url or rc_url:
                    self.job_links.append(self.base_url + link.strip())
    def get_job_info(self):
        job_listings_url = []
        for link in self.job_links:
            print("    Scraping: ", link)
            driver.get(link)
            driver.implicitly_wait(2750)
            getTitle = self.driver.find_element_by_xpath('//h3[@class="icl-u-xs-mb--xs icl-u-
xs-mt--none jobsearch-JobInfoHeader-title"]').text
            _soup2 = bs(self.driver.page_source, "lxml")
            self.title = _soup2.find("title").get_text()
            self.job_descs = _soup2.find_all('div', 'jobsearch-JobComponent-description icl-
u-xs-mt--md')
            self.job_origins = _soup2.find_all('div', 'jobsearch-JobMetadataFooter')

           #  self.job_title = re.findall("(.+) - .+ - .+", self.title)[0]
            self.job_location = re.findall(".+ - (.+) - .+", self.title)[0]
            self.description = "
```

```
        for d in self.job_descs:
            self.description += d.get_text("|", strip = True)
        self.origina = re.findall("^.+ ago", self.job_origins[0].get_text())[0]
        jobs = {
        "JobTitle": getTitle,
        "Location": self.job_location,
        "JobDescription": self.description,
        "Origin": self.origina,
        "Url": link
        }
        job_listings_url.append(jobs)
        allUrlsInfo.append(jobs)
if __name__ == '__main__':
  defaultPerPage = ["10", "20", "30", "50"]
  searchFor = input("Enter The Keyword you want to search for: ")
  n = int(input("Enter no. of pages to scrape: "))
  perPage = input("Enter the number of results you want: You can only type: 10, 20, 30,
50: ")
  if perPage not in defaultPerPage:
    print("Invalid Per Page Entry")
    exit()
  keyword = (searchFor).replace(" ", "+")

  n = n*10
  driver =
webdriver.Chrome(r"C:\Users\Administrator\Desktop\indeed\chromedriver.exe")
  for i in range(0, n+10, 10):
    ext = "/jobs?q=" + keyword + "&l=United+States&limit=" + perPage + "&start=" +
str(i)
    s = SoupMaker(ext, driver)
```

```
    s.read_page()
    s.get_job_url()
    s.get_job_info()
searchForSantize = re.sub('[^A-Za-z0-9]+', '', searchFor)
localtime = time.strftime("%Y%m%d-%H%M%S")
with open('%s-%s-result.csv' % (searchForSantize, localtime), 'wb') as csvfile:
    fieldnames = ['JobTitle', 'Location', 'JobDescription', 'Origin', 'Url']
    writer = csv.DictWriter(csvfile, fieldnames=fieldnames,quoting=csv.QUOTE_ALL)
    writer.writeheader()
    for data in allUrlsInfo:
        writer.writerow(data)
driver.close()
```